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Photos by Manuel & Herbert.

French soldiers making wooden soles for army shoes

SHOES OF THE FRENCH SOLDIER [See page 184]

The Rubber Industry*

And What Science Has Done for It

By J. Bretland Farmer, M.A., D.Sc., F.R.S., Professor of Botany, Imperial College of Science and Technology

AGRICULTURE, generally, is at bottom an essentially scientific industry. Its carrying on, and especially its reasonable extension, depends fundamentally upon the utilization of natural knowledge, which is natural science. The knowledge may be largely empirical, it may be very imperfect, but it must be there in some measure; indeed, below a certain level of knowledge the tracks are apt to lead straightway toward insolvency. In tropical agriculture this truth is more evident than at home. But that is only because in Europe we have a wide experience, reaching back for many generations to go upon. In the tropical cultivation of the ancient crops practice is also, up to a point, admirable if somewhat stereotyped, just as it is among the old-fashioned folk at home. But a *new* industry, developed under modern financial and other conditions, calls for new practice. New wine is said to burst old bottles, and we have had already some sharp lessons in the tropics on the folly of neglecting to get Nature ranged on one side in exploiting the natural wealth which lies to the hand of him who knows how to gather it.

Such an industry as that of plantation rubber is essentially a branch of applied science. The trouble that lies at the root of things is that people do not sufficiently realize what they mean by science at all.

Let me put the matter in another way. We can of ourselves never produce anything in this world—neither rubber nor anything else of a material kind. We cannot make a rubber-tree, nor can we make it grow or yield anything. What we can, and actually do, effect is to arrange the conditions within certain rather narrow limits, but the rest of the affair—the genuine constructive work—lies altogether outside our powers. It is here that knowledge comes in, the knowing of the conditions which are requisite in order that what we desire may be accomplished by the forces of Nature, so far as it may be within our power to coordinate their operation, and so to secure the object we have in view. This is why it is so much easier to destroy than to construct. A relatively small derangement is enough to bring about destruction; sustained effort and continual watchfulness are demanded to ensure that the forces we imperfectly understand, and only partially control, may act in the desired way over a period of time which may be, and commonly is, of long duration.

How, then, does the particular sort of knowledge which we call science differ from that which is reached by the empirical method of trial and error? As we have seen, the latter can carry us very far, though it is expensive to acquire. In ordinary agriculture it has taken us a long way and has reaped a large measure of success. But it has been acquired wastefully, and many of the trials have been ruinously unprofitable. Now it is the chief business of science to detect the hidden relationships of cause and effect. The phase may be simple but if you try to analyse it, and so see what it really implies, you will soon discover it is not so simple as it looks at first sight. In Nature we hardly ever encounter a straightforward problem. Before it can be usefully attacked it has to be split up into a number of more elementary ones—easier to grapple with, but, unfortunately, not always easy to solve. When we have disentangled, or analysed, the immediate problem into its simpler components, and some of these have been more or less fully unravelled, we have really learned much which, though perhaps not directly convertible into cash value, may well put us in a position so to improve empirical practice that the cash will flow in.

The German chemists spent large sums of money variously estimated at a million or more sterling, in breaking up the big indigo problem into its simpler parts before they had found out enough about the matter to enable them well-nigh to ruin the indigo plantation with their synthetic product. Similarly, unless we succeed in properly and intelligently harnessing the natural forces, and in manipulating the natural material basis for the plantation rubber, it may well happen that the chemist will discover how to bring about, on a commercially paying scale in the factory, what the rubber plant effects within its own body—the production of cacoutchouc. If he ever does this on a successfully competitive scale, the planting industry will have itself to thank for the closing down of the plantations. The raw materials, chiefly carbon dioxide and water, are available everywhere, and are abundantly at the disposal of the plant, while the sunlight which drives the living machinery is free to utilize. And if the planting industry fails to keep uppermost in a competition where the rival is handicapped with relatively costly raw materials, it will be due to a short-sighted reliance on defective or depreciated plant, and possibly to unimproved vital machinery which is not being economically driven by the sun's energy. In other words, to a neglect of disease and to a lack of breeding better strains of rubber plants.

It is fair to learn from others, even from our enemies. Thirty years ago the yield of sugar from sugar-beet was scarcely half what it is today. The agriculturists, largely German, cooperating with scientific men, rapidly improved their strains of beet, and succeeded in largely undercutting the product of the sugar cane, mainly because the West Indian planters continued to employ methods—if they could be called methods at all—which could hardly end in any way but disaster. I well remember the surprise I felt some thirty-five years ago at finding a beautifully equipped laboratory attached to a very small factory erected for the extraction of sugar in a Hartz mountain village. The laboratory was provided with all the latest apparatus, and was in the charge of a very able man. Nothing was left to chance, and every effort was made to understand the how and the wherefore of sugar production, not only from the beet in the factory, but from the raw materials in air and soil when they meet within the tissues of the beet. In such centres, and they were many, knowledge was being made, and although the problems that confronted those early inquirers were far less susceptible to analysis at that time than at the present day, the patient and dogged determination to improve the stock and the methods has justly earned a rich reward.

Now let us turn to the rubber industry and try to see how we stand in this matter. After a number of tentative attempts with a variety of rubber-yielding plants—*Ficus*, *Castilloa*, *Funtumia*, *Manihot* (Ceara), and others—the plantation industry has mainly centred its efforts on *Hevea*. It is not necessary to detail here the romantic episode of its acquirement, through Wickham, by Kew, and its distribution by that great establishment to the tropical regions of the Empire. But it should not be forgotten that this great wealth-producing agency in the British Empire was cradled in the scientific nursery at Kew. As it advanced to the productive stages it has continually invoked the assistance of science, which has been repeatedly able to short-circuit the dangerous and devious road of empiricism—a road strewn with the corpses of more than one industry, as in Ceylon and elsewhere. Soon after its introduction the inevitable onslaught of disease occurred. At first came the serious attack of *Fomes*, and mycologists were engaged to study the fungus and to devise remedial measures. That particular disease is now pretty well understood and under control, and I have met men who are inclined to think that the value of the scientific assistance rendered in that connection has been somewhat overrated. Such an attitude is plainly untenable. Because the remedy happens to be simple when you know what to do, when to do it, and how to apply it, the value to the industry of being in a position to adopt remedies at all is supreme. Such measures, however, could have only been employed when the full story of the cause of the disease has been elucidated, and for this the scientific methods of men specially trained in the laboratory and in the field were absolutely indispensable. When *Fomes* had been pretty well subjugated it was supposed by some that the troubles were at an end. But those who were accustomed to think in terms of cause and effect, whether they called themselves scientific or practical men, knew better. You cannot grow a huge, and practically continuous, acreage of any species, especially under tropical conditions, without a constantly present risk of the incursion and rapid spread of animal or vegetable pests, and in disease it is during the earlier stages, before it has got a big hold on the crop, that it can be most hopefully combated. Other diseases have made their appearance. Pink-rot, which spread with terrible rapidity, and almost threatened the very existence of the industry itself in some districts, was only got under control when the source of the virulent infection was discovered, by the efforts of Brooks, Sharples, and others. Root-collar disease has likewise proved a dangerous pest, but now that its life-history and its mode of attack are understood, it should also become amenable to control. The more recent onslaught of *Phytophthora*—akin to the potato blight at home, and especially in its ruthlessness—is giving trouble, especially in Malay, where it has recently appeared. A similar, and perhaps identical species, investigated by Petch, has been known for some years in Ceylon, where, however, it does not appear to be especially dangerous. But it must be borne in mind that it by no means follows that a disease which is virulent or mild in one climate or soil will necessarily preserve the same characters in regions where the physical or climatal conditions are different. The *Phytophthora* will need careful watching, especially in continuously damp climates.

It is not in the slightest degree probable that the planter will have peace from the attacks of fresh, and as yet unknown, pests. The history of plant pathology contains many records of fungi and other organisms which, from apparently relatively harmless antecedents, break out as violent parasites, whenever they find suitable host plants, which are constitutionally unable to keep them at bay. It must be remembered that these lower organisms produce countless hordes of spores or germs, which are, moreover, easily distributed very widely, and if any of them happen to fall on an appropriate nidus, such as a suitable plant not specially protected, they will almost inevitably force an entrance with, it may be, disastrous results if timely measures are neglected.

Now, the rubber tree (*Hevea*) is not indigenous in the East, and we may take it as quite certain that there are many fungi and similar organisms, to say nothing of insects, against which it has no immunity, and to which, when the opportunity arrives, it will fall a prey unless extraneous and effective help is given. And in all these matters there is no time to waste in blind empirical trial. What is wanted is the very best advice that can be obtained, and it ought to be available at once.

In the West Indies, where the planting of *Hevea* has, save in a very few estates, hardly got beyond the experimental stage, there has been no little trouble as yet. But the history of every new tropical enterprise is much the same in this respect, and the West Indian, like the Eastern planters, are likely to have enough on their hands. The case of sugar will not be forgotten by the enlightened body of men who are advising the West Indian estates.

But while the problems of dealing with diseases have imposed, and will continue to impose, upon any planting community the need of maintaining a scientific staff to look after the sanitation of the trees, even if it is only urged thereto by elementary considerations of common prudence, there are other aspects of scientific assistance which ought not to be lost sight of, as they are rather apt to be so long as the necessity seems less stringent.

There remains much still to be learned about such relatively simple matters as tapping the trees. Parkin made a notable discovery when he established the existence of the wound response; and others, by anatomical investigations, have shown that the laticiferous system of tubes does not run vertically but spirally in the tree. This has given an important clue to a rational method of arranging the cut. But these things are, after all, only the fringe of infinitely more important problems which ought to be seriously tackled, as they would have been tackled long ago if the leaders of the rubber enterprise had fully understood the power which a scientific knowledge of their living machinery is able to place in their hands. These all-important matters which I now have in mind may be shortly stated to be, first, the physiological significance of the production of rubber and its chemical antecedents, not to the *planter*, but to the *plant;* and, secondly, those scientific investigations which are conveniently summed up in terms of stock-breeding. Now these are large matters, and before they can be brought within the tangible reach of practice a good deal of what is sometimes called pure science will have to be invoked. One is liable, when urging an embarkation on a research conducted without any *immediate* practical object in sight, to be reminded that the practical man is out to make money, and not to subsidize pure scientific research, which does not obviously or directly contribute to this result. This attitude is largely due to a misapprehension of the methods of science. In the larger affairs of life and business, it is not a paying or long-sighted practical policy to condemn the expenditure of every sixpence on Monday which fails to yield an obvious shilling on Tuesday. Still less is it a far-sighted view that nothing is likely to matter much to a concern, even one in which large risks are taken because it has hitherto been able to pay a big dividend. What does

*From the *Jour. of the Royal Soc. of Arts.*

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matter is the establishment of a sound policy while business is good, and the furthering of future interests while things are still going well. Hard times and the stress of competition will come to rubber as to other industries, quite apart from the present difficulties. And one of the sides from which the attack is bound to be delivered is the chemical one.

Now chemistry has served the industry fairly well so far. The different coagulation methods, vulcanization,[1] and various other ways of dealing with the latex and its products, have formed essential stages in the successful development of the industry as a whole. But chemistry is a two-edged blade, and when synthetic rubber begins to loom seriously in the future as a commercial proposition what will the planters and the shareholders in the plantations have to say to it? At any rate they have done practically nothing to forestall it up to the present time.[2] Although the matter is attracting some attention in the circles that largely control the industry, there is little evidence at present of any adequate appreciation of the real nature of the task with which they are confronted. It is not, of course, unlikely that some improvement may be effected by mere empirical selection, whether of cuttings or by seed. But it is well known that there are rather special difficulties in the way, quite apart from all questions of influencing resistance to disease. For example, a tree may yield well for a time, and then fall off, only to become a good yielder later on. Others again behave differently, and are regularly either good or bad. But these facts evidently afford important clues to profitable lines of investigations in the future. Meantime breeding work is being conducted in Ceylon and perhaps elsewhere—a beginning has been made in a very small way at Singapore—on an altogether preposterously inadequate scale.

Furthermore, unless breeding operations are placed under the direction of men who thoroughly understand what they are about, and who are aware of the great complexity of the problem, the money and time expended will almost certainly be thrown away.

Breeding experiments are hardly likely to be of much value if they are confined to empirical and haphazard lines. A well-staffed and well-equipped experimental station and laboratories, devoted to breeding and kindred problems, ought to be provided in each of the main rubber-growing regions, and there ought also to be a settled policy of research. And by research I do not mean a concentrated effort to grasp at once at practical results, but to acquire knowledge—knowledge which when properly utilized will pay well. It is no use expecting to get big results in a few years, and hence the stations must be placed on a practically permanent basis. Nor is much likely to come from an establishment in which only breeding, in its narrower sense, is conducted, and it is but fair to put this aspect of the case forward. I suppose if one were to ask a planter what he expects to get out of the money devoted to maintain a breeding institute, the answer would be, Better yield, and a stock more immune from disease. This latter point is, however, fraught with especial difficulties, particularly if it has to be (as it should) combined with increased yield. For a moment's reflection will show that diseases are many, and their modes of attack diverse. Hence it is not all probable that we shall ever raise a stock capable of withstanding all pests, although it may well be that resistance to some will prove to be quite within our power. Nor is any full measure of reward likely to accrue from breeding for yield, until we know something definite about the factors of which yield of caoutchouc is an outcome. But please do not think I take a gloomy view of future possibilities. The possibilities are great, but they will only be realized if we set about intelligently to make them materialize. We shall want, to begin with, real and accurate knowledge as to the significance of rubber and its chemical precursors in the tree. This will give us a genuine basis on which to go ahead, for it will afford clues which are as important from a breeding point of view as they are from a cultural one. In other words, we shall have begun to dissect the big complex problem into smaller ones, for which we may hope sooner or later to discover the solutions. But the sort of knowledge required is not mere speculations, such as whether the use of the latex is to heal wounds, or render the plant distasteful to animals, or any of those other functions which idle and rather childish guesses have suggested for it. We want to know precisely what is its physiological meaning, and all about its actual formation, and then we may hope to realize and control the conditions that make for its production within the plant. That it is related to the carbohydrate metabolism is certain, and that it stands in some sort of connection with resin is also pretty clear. And this last is a point of special interest, inasmuch as resins are present as more or less of a nuisance in all latices. The problem is not a simple one. Its solution may well tax the brains of the ablest men. But without doubt it ought to be taken seriously in hand, and that with as little delay as possible, for it is of really first-rate importance. It may be that the full solution is still far off, but the knowledge gleaned by the way is certain to repay the outlay—but only on one condition, that really able and well-trained men are engaged upon it. Anything else will be merely throwing time and money away.

Another set of problems will have to claim the attention not of rubber-planters only, but tropical agriculturists generally. In Europe and America the soil has, for some years, been looming ever larger in the minds of far-sighted men who are directing the higher agricultural practice. With more intensive cultivation, and the much greater yield arising therefrom, the soil has had to be investigated from the chemical, physical, and the biological points of view. The upshot of the whole matter has been to emphasize the unexpected importance of the biological aspect of the case. The fungal flora and the micro-organisms of both animal and vegetable nature exercise an immense influence on the fertility or otherwise of the soil.

In the tropics the soil problems are bound to call for a far greater share of attention than they have hitherto received. In Ceylon, for example, it is generally recognized that there are difficulties in replanting estates. The action of the sun and rains on the land tends to destroy its fertility, partly by the mere physical action of removal, but partly also by the prejudical effects of direct sunlight on the soil. The problems are not quite identical with those that are before us in the temperate climates, but they are not less important if we desire not only to increase, but even to conserve the capital value of the land.[3]

I have endeavoured to indicate very briefly some of the main directions in which science has aided, and in which it can further aid the great tropical plantation industry. I have also attempted to point out some of the chief difficulties that lie in the way of rapid results, because expectations unduly aroused are apt to be followed by correspondingly unfounded depression, if not by irritation. It now remains for me to venture to suggest certain quite general lines on which this assistance, so essential to the well-being of the planting industry, might be most usefully increased and organized.

It must, I think, be clear to anyone who has watched the progress of most of our great commercial enterprises, that one of the commonest causes of arrest or decline lies in a certain lack of imagination which seems to be one of our national defects. The bird in the hand is really not always worth two in the bush, but we are rather too apt to grudge expenditure which gives no immediate promise of a tangible return. Our attitude to so-called "applied science" affords an illustration of this. Thus, when we have grasped the fact that we require scientific assistance to enable us to cope with the natural difficulties of disease and so on, we get out our mycologists, chemists, entomologists and what not, and then set them down mainly to do routine work—to deal with current difficulties only. No serious attempt is made to tackle the really big problems. We have, as I have already remarked, no adequate establishments to deal with the important matter of breeding. It is true that Ceylon has advanced a little—a very little—way in this direction. But it is quite certain that nothing very much can reasonably be expected to come of it on the present lines. Provision in the tropics should be made for such work on a liberal scale, and there ought to be no question of a five or ten years' scheme, but it will have to be secured on a permanent basis if any real good is to come of it. A well-staffed and well-found establishment will certainly, in the long run, repay all the expenditure many times over, but results of immediate practical value are not likely to come in this or next year, nor ought they to be expected or demanded.

This is perhaps not the occasion on which to raise or to discuss details of high policy, but in general terms it is safe to say that the matter ought to be taken in hand by the governments especially concerned, and administered by a body on which the planting industry and also the relevant branches of science, are properly represented. Such a combination of official, practical and scientific men ought to be able to ensure that the work would be carried out on well-considered lines. The three lines of interests, if I may use such a term, would view the matter from different angles, and although there might be differences of opinion as regards details, the general outcome of such cooperation should make for real efficiency. But, as I have already said it would be essential that the enterprise should be definitely freed from the start from all demands for early practical results. And furthermore, when once the general lines have been laid down, and good men have been secured, those responsible for conducting the experiments must be given as free a hand as possible—and the less said about time-limits the better.

I believe it would be of great advantage if a suitably constituted committee were formed to serve in this country in connection with any such schemes. The functions of such a committee evidently should not be administrative, otherwise friction would almost certainly arise, and it might seriously impede the usefulness of an institute working in a distant country and confronted with conditions that might be imperfectly understood by persons living at home, and unfamiliar with local circumstances. But a home committee, charged with advisory functions only, would serve the useful purpose of bringing the tropical institutes into direct contact with the clearing-house of European knowledge, both economic and scientific. From the latter point of view at any rate, such a connection would seem to be eminently desirable, inasmuch as the results of the rapid advances which are being made in scientific knowledge and outlook would thus be rendered easily and naturally available to those engaged on the more specialized work of the institute or institutes. And such an association or committee, by furthering the aims and objects of the several institutes that may be brought into being, could not fail to react beneficially on the planting industry as a whole. Its efforts should be the more acceptable since matters affecting individual trade interests would lie entirely outside the terms of its reference.

Of course the scheme would cost money, but the expense would be very small in comparison with the magnitude of the interests at stake.

To sum up then, science has been invaluable in the service of the rubber plantation industry, both from the chemical and also, and especially, from the biological side. If the industry is to continue to prosper, it has become essential that the investigations of disease and immunity, of the mode and significance of the latex and its constituents within the tree, as well as of the breeding of better stock, shall not only be maintained at their present level, but considerably increased. A distinction will have to be drawn between the necessary routine, *i. e.*, scientific sanitation and inspection work on the plantations, and the research work largely to be carried on in the institutes. Both are essential, if the true interests of the rubber-planting enterprise and its future growth and prosperity are to be adequately safeguarded.

Meanwhile no one with a knowledge of the facts can doubt that, given a proper cooperation of science with practice, a larger—a much larger—return of rubber per acre is possible, and that this will be one of the most effective means of enabling the plantations to hold their own against competition and danger, whether from the synthetic factory or from other sources.

[1] Plantation rubber still needs much chemical investigation in order to perfect its most profitable vulcanization.

[2] An American combine in East Sumatra is doing, with characteristic thoroughness, far more than the British organizations. They employ a staff that is both adequate and well paid, and will certainly reap a well-deserved profit.

[3] The American combine already alluded to have a soil-chemist on their scientific staff.

Silver Acetylide

THE noise accompanying explosive decomposition is due to sudden alterations in the gaseous pressure occurring with a velocity of the order of that of sound. The acetylides of the heavy metals, *e. g.* silver acetylide, in decomposing, might be expected to give rise to carbon and metal only and therefore the explosion should be quiet except for the sudden disturbance in the surrounding air. However, silver acetylide, especially if prepared from a solution of silver nitrate in aqueous nitric acid, explodes with great violence and noise even in a vacuum, whereas with a product precipitated from an ammoniacal solution of silver nitrate the explosion is much milder. The explanation of the vigor of the explosion and of the difference between the behavior of the two varieties is to be found in the fact that the explosion does give rise to gaseous products, the "acid" variety yielding 17.2 c. c. of gas (N. T. P.) per 0.1 grm. of substance, while the "ammonia" variety yields only approximately one-tenth of this amount. The gaseous products consist of water vapor, hydrogen, oxides of carbon and methane, together with oxides of nitrogen in the case of the "acid variety"; these must be due to the presence of occluded silver nitrate and silver oxide respectively in the "acid" and "ammonia" products. The latter variety is obtained purer, the lower the concentration of the silver and the greater the proportion of the ammonia. The disruptive power of "acid" silver acetylide is greater than that of silver fulminate but less than that of silver azide, the difference being attributed to difference in the velocities of detonation.—Note in *J. Soc. Chem. Ind.* on an article by J. EGGERT in *Chem. Zeit.*

The Common Snails*

Their Relation to Balanced Aquaria

By Ida M. Mellen

BALANCED aquaria, whether of salt or fresh water, are never quite satisfactory without snails; and most snails, especially very active varieties, are so attractive that no one who observes them closely can help developing some interest in them.

The snails are members of that group of molluscs called gasteropods, which are characterized by an unsymmetrical body, a well-developed head, and a one-piece or univalve shell which is readily distinguished from the double or bivalve shells of clams and oysters.

The amount of oxygen in the water is supposed to determine the growth of the shell.

Snails differ in habits and structure. Some (principally the land and fresh-water species) have lungs, while others (mostly the marine forms) breathe with gills. There are certain kinds which die very soon if they become dry. and others, after spending years in a naturalist's cabinet, apparently dead, have been known to resume activities when placed in water. Some are separately sexed, while others are not. Most snails lay eggs, but a few bring forth their young alive. The hard shell of certain species, provided with a horny door or operculum with which the animal closes the shell's opening after retreating within, serves as a protection against enemies; others, with thin, doorless shells, are defenseless and fall easy prey to aquatic insects, beetles and fishes.

Shells are subject to erosion from the action of chemical and mechanical stimuli upon the prismatic layer.

The tongue of the snail, also called a lingual ribbon, is set with even rows of minute teeth, only the forward sets of which are used. As these wear down, the rows behind, which are continually being formed, move forward on their membrane, and by this process of constant renewal the snail is always in possession of a serviceable rasping apparatus. This is drawn back and forth over a plant leaf or other edible substance, scraping and comminuting it preparatory to swallowing.

The eyes are generally situated at the base of the tentacles.

Snails possess some powers of regeneration even in the shell; and a hole cut in the shell of a common pond snail was observed to heal completely in six weeks.

Salt Water Snails.—The Periwinkle (*Littorina littorea*), though prettily shaped, is not hardy in balanced aquaria, nor particularly to be desired because of its preference for a vegetable diet, which is inimical to the aquatic plants. If one lives near the seashore, however, he may keep periwinkles in his aquarium for a few months by feeding them with sea lettuce, which they will eat fresh or partly decayed. If provision is made for them to crawl up out of the water, they will do so, clinging to a stick or stone for hours as though waiting for the tide to rise.

The Seaweed and Salt Marsh Snails (*Littorina palliata* and *Melampus bidentatus*) are also vegetarians, and fishes prey upon the latter.

The Oyster Drill (*Urosalpinx*) is a handsome little shell and will survive for some time, but as the presence of an oyster or clam is highly desirable for clarification in the salt water balanced aquarium and this small carpenter will bore his way through either, it is obvious that the helpless giants must not be placed at the mercy of the Lilliputian. In truth, no other molluscs, even small ones, can be maintained with the oyster drill, which is a thorough cannibal.

Other seashore snails, such as the Rock Snail (*Purpura lapillus*), whose natural food is barnacles, have proved fairly hardy in the home aquarium, but experiments to date point to the conclusion that the best of all salt water snails for this purpose is the mud snail.

The Mud Snail (*Nassa obsoleta*) is found in all parts of the world. On the Atlantic coast, from Massachusetts to Florida, it is the commonest of small molluscs, darkening the rocks and infesting mud flats and tide pools.

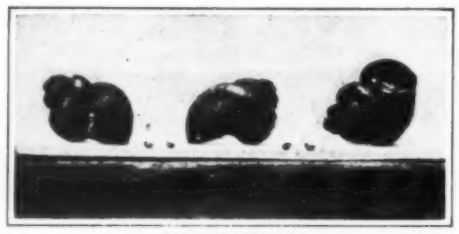
When adult it moves only on solid surfaces, though the young hang by the foot to the surface of the water after the manner of fresh-water snails. Miss Dimon, who has made special studies of this species, thinks it effects locomotion by the extrusion of mucus, "affording a semi-solid rod against which to push." This is probably the method of locomotion of many snails. However, considerable difference of opinion exists on this point, some observers maintaining that snails move by muscular contraction and relaxation of the foot, other theories variously holding that they effect locomotion by means of a blood flow to the foot tissues; by peristaltic contraction of the foot in undulatory waves; by action of the cilia on the foot and not by motion of the foot itself, etc.

The mud snail requires considerable oxygen. Its siphon supplies the gills with oxygen from the water when submerged, while, when left dry at low tide, air is inhaled through the siphon and life sustained as long as there is some water remaining in the mantle cavity.

Left: Oyster drill. Center: Seaweed Snail. Right: Perriwinkle

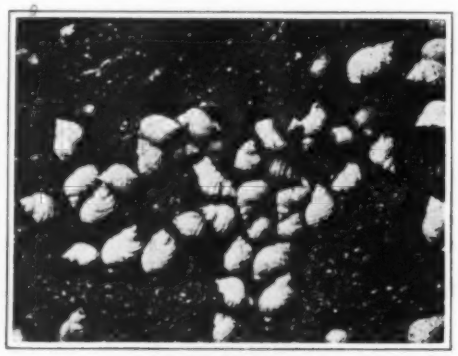
Moisture is necessary to its existence, and it dies much sooner when deprived of it than when prevented from rising to the surface for air. Indeed, it is a burrower, and will bury itself in the mud and remain quiescent for a considerable period.

The sexes are separate but there are no external distinguishing marks. Under natural conditions eggs are laid during the warm months. In small aquaria they



Potomac Snails

appear at all seasons on the sides of the tank or attached to the sea-lettuce. The egg capsules, shaped like miniature urns, are dirty white, semi-translucent, and may contain as many as seventy-five ova. The young hatch as invisible, free-swimming veligers, and, for several days prior to leaving the egg, the cilia of their large "ears," under magnification, can be observed already in rapid vibration. The shell is only partly



Rock Snails

formed at hatching, but a couple of weeks' growth completes it, and the tiny creature now having lost its means of locomotion, no longer swims, but, snail-like, crawls on its large foot.

Typical of snails, this species is a scavenger. It takes food only under water. It will eat algae and sea-lettuce but does little damage to the plant life of the home aquarium. Its favorite food is fresh meat in the shape

Fresh Water Limpet

of other molluscs, worms, shrimps, crabs and dead fish, and it will assiduously clean up all the scraps from the aquarium, only the eel surpassing it in scavenging ability. For a slow-moving animal, burdened with a shell uncommonly heavy in a mollusc of its size, it is extremely voracious. It is recorded that several together have been observed to capture a clam-worm (*Nereis*) and devour it alive, though we suspect that the worm must have been caught napping.

The mud snail is nearly black. The upper surface of its foot is heavily pigmented, and the under or crawling surface is pale gray. The shell is marked with deep, brownish grooves, and is so much subject to erosion that some specimens are worn away to the innermost layer. When full grown it measures about an inch in length. The operculum is small, only partly closing the opening of the shell when the body is withdrawn.

The animal often carries around a pretty little roof garden of waving green algae, and occasional specimens are so densely overgrown with the fringe-like plant *Enteromorpha*, that at first glance they might be mistaken for sea mice.

The species is unique in the possession of a long inquisitive siphon that can be turned in any direction, and which, traveling on before like an elephant's trunk, tells its owner the nature of the object it is approaching.

Small aquarium fishes do not molest it, and next to the minnows, eels and shrimps in activity, the mud snail, without which no salt water balanced aquarium can be complete, serves as a useful and interesting pet.

Fresh Water Snails.—There are numerous species of American fresh-water snails, and most of them are preyed upon, either in the young or adult stage, by fishes. One of the few that attains a length greater than one inch, is said to avenge all the others by attacking and devouring little fishes.

The two species most commonly used in our balanced aquaria come from other shores: the Red Ramshorn of Europe and the large brown Japanese Snail.

The commonest of American fresh water snails are the Pond Snail (*Lymnaea*), its near relative *Physa*, the little fresh water limpet, *Ancylus*, the coiled shells called ramshorns, and the Potomac snail.

The horn-colored fresh-water limpet, or rover limpet (*Ancylus*), is a very small, sluggish and almost flat snail. It is a lung breather and has been observed to spend an entire winter out of water. It is hardly above a quarter of an inch long, and desirable only in an aquarium for animals smaller than fishes, since the latter will prey upon it.

Physa is one of the species credited with resisting desiccation. It is a spiral snail with no operculum and a thin shell easily crushed in a fish's jaws; and most species of the pond snail answer the same description, being thin-shelled and doorless like *Physa*, slightly longer and more pointed. One species of the pond snail, however, found in northern New England (especially in Vermont) and called the Niagara snail (*Lymnaea stagnalis*), grows to be two inches in length and is large enough to be kept with goldfishes. But it has the reputation of capturing little fishes such as sticklebacks, also small salamanders; and it will attack the plants if not provided with special food, such as lettuce.

The common pond snail is the most interesting of fresh-water snails, a pulmonate—that is to say, an air breather, having a lung and no gills. Crawling upside down, at the surface, on its broad, flat foot, it imbibes air so audibly that even small specimens can be heard sucking it in, and feeds on floating vegetable and animal substances. Drawing small edible objects to its foot, which is provided with threads of fine cilia, whose action attracts like a magnet, it curls the foot so as to hold the food substances thus captured, and carries the repast below to be devoured under water. It can drop to the bottom or rise to the top in an instant, and all feats of aquatic motion are familiar to it except that it cannot swim through the water like a fish.

Its most interesting performance is the manner in which it ascends from the bottom on a string of mucus extruded before it as it rises, later descending upon the same string. These mucus strings are invisible unless they remain long enough to gather a covering of silt, but their presence is easily detected by passing a stick over or under the suspended animal.

The pond snail is omnivorous, feeding largely on vegetable substances, but refusing nothing that is edible. A defunct comrade is soon cleaned out of its shell, and no scraps left by the fishes will escape the snail's attention. It is hermaphroditic, both sexes being present in each individual, but the eggs are cross-fertilized. The eggs number from seventy to one hundred, according to the species, are laid in horseshoe-shaped masses of gelatin attached to plants or to the sides of the aquarium, and hatch in two or three weeks.

The ramshorn shells are of a very ancient type, being found in fossil remains of great antiquity. They are of

*From the *Bulletin* of the New York Zoological Society. Illustrations from Sea-Shore Life and pen drawings by author.

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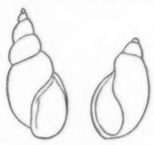
numerous species, the commonest being the brown *Planorbis*, a clumsy snail measuring scarcely more than half an inch in diameter. It lays about eighteen yellow eggs in gelatin and does well with little fishes such as shiners, banded minnows and dace. It often carries on its back a menagerie as well as a roof garden, colonies of protozoa and rotifers, water bears and other minute animals. Specimens are said to have become active after being without water for four months.



Left: Pond snail. Right: Physa. Physa is a near relative of the pond snail. When held in the same position, one shell opens to right and the other to the left

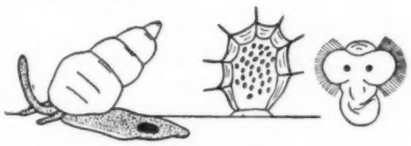
There is a ramshorn shell (*Planorbis magnificus*) indigenous to certain streams of North Carolina, that is the giant of its type in this country, some specimens measuring one and three-eights inches in diameter. It is called the Cape Fear River Snail. It has been observed chiefly for scientific data, has eyes when young which later degenerate and, becoming covered with cuticle, render the adult sightless. It is probable that the rarity of this large shell will prohibit its general introduction into home aquaria, although, as its name indicates, it is a magnificent snail.

The European Red Ramshorn (*Planorbis corneus rubra*) originally introduced from Germany and numbers of which are now bred in America, is the ramshorn shell most commonly used in home aquaria; a handsome, active snail an inch and a quarter in diameter, ruby bodied and ruby-shelled when young, the shell becoming striated with brown and black as its size increases. It is also called Copenhagen, Coral, and Red Post Horn Snail, and occasionally Trumpet Snail. It breathes by means of a lung, often visiting the surface for air, and manages its shell more dexterously and gracefully than the American *Planorbis*, never giving the impression that it labors under an embarrassing weight. This is partly due to the advantage of having a longer body to control both the foot and the shell. Like most pulmonate shells (lung breathers) it is hermaphroditic and cross-fertilization takes place. The pink eggs, numbering from ten to forty-five, are enclosed in an ovate mass of gelatin attached to the stems of plants.

The eyes and the siphon (which is at the side of the shell, behind the body) are enormous in newly hatched specimens, and the shell at birth is thimble-shaped and shows no convolutions, the color being dirty yellow with faint touches of pink. The baby snail just out of the egg is barely visible to the naked eye, but begins activities at once, and can travel an inch in five minutes.

The eggs are preyed upon by microscopic animals of various sorts, but given a clean aquarium, a little lettuce and scraps of meat or fish, with chalk, gypsum, ground coral, plaster of paris or cuttlefish to provide lime for the growing shells, and the red snail will breed rapidly. It is desirable to place only full grown specimens with fish, the younger ones being likely to fall prey to their finny companions. The red color is, speaking eugenically a recessive trait, and is lost if the snail is bred with our native, sombre-hued ramshorns.

The Potomac Snail (*Viviparus viviparus*, formerly *Paludina*) and the Japanese Snail (*Viviparus malleatus*) have the fault of becoming somewhat dormant in the winter, moving about only on the milder days or when the sun is upon them. The Potomac Snail, whose shell measures an inch and a half in length, is generally more sluggish than the larger Japanese variety, which is over two inches long. This sluggishness is so dominant a quality that those who have interbred them record the resulting progeny as sluggish and short-lived as the Potomac Snail. The males of both species have one tentacle shorter than the other, while those of the female are of even length.



Mud Snail, egg case and young. Egg case and young much enlarged

Both the Potomac and Japanese Snails are ovoviviparous, the eggs being retained within the mother's shell till they hatch. The young shells are hard enough at birth to protect them from small aquarium fishes. It is believed that the female of the Japanese snail after once mating, remains fertile the remainder of her life. Both species have remarkably small appetites, yet help to clarify the aquarium, and are of an ideal size to be kept with goldfish. They are gill breathers, not needing to rise to the surface for air, and have a horny operculum for the complete closure of the shell.

The dark brown shell of the Japanese Snail often presents a fuzzy green aspect, because of the dense growth of minute plants with which it is overgrown.

The fertile specimen the present writer has observed, produced fourteen young in seven days and then rested. At birth the Japanese Snail is larger than the Potomac, and is an exquisite creature, of a delicate gray tint with slender brown tentacles and a single brown band in the translucent shell.

A European snail now bred in this country and to some extent used in home aquaria, is the Transparent

Red Ramshorn Snail and young. The young, much enlarged, shows marked difference in shape of shell and size of eye and syphon

African Snail, also called African Paper-Shelled Snail (*Lymnaea auricularia*). It has a light horn-color shell over an inch in length and a spotted bown body. The eggs and young are preyed upon by fishes and only adult specimens are therefore desirable for aquaria. It is a short-lived rapidly-breeding species and an excellent scavenger. In shape the shell is similar to that of the common pond snail except that the opening is much larger giving it the popular name of Ear Shell. It has a broad body whorl and depressed spire.

The Four Horned Snail (*Ampullaria gigas*) from South America is a vegetable feeder and destroys plants indiscriminately. It is large like the Japanese snail and has the peculiar habit of laying its eggs above the water in such a position that when the young snails hatch they may drop into the water immediately. Another snail of the same family *Ampullaria pinei* from Florida, grows over three inches long. These snails are attractive and a study of their habits will afford many pleasant and profitable hours; but if one wishes snails only to act as scavengers in his aquaria the most desirable are those which will not attack the plants except to keep the fine plant growth cleaned off the glass, and will consume the scraps left by the fishes.

The best fresh-water snails for this purpose that are readily procurable are the European red ramshorn, the Japanese snail and—when it is not asleep—the Potomac common in nearly all our ponds and lakes. Of these the last two are the cleanest, but the red ramshorn is the best scavenger though necessarily requiring more care and will survive several years in captivity. More than one variety of snail is not amiss in an aquarium since tastes differ even among snails.

On the Correction of Optical Surfaces

By A. A. Michelson

Ryerson Physical Laboratory, University of Chicago

In a recent number of the *Philosophical Magazine* an interesting method for correcting optical surfaces by means of the interferometer was developed by Mr. Twyman. While nothing in the paper indicates that the method is limited to relatively small surfaces it would appear that such an application to mirrors and lenses of the size of modern astronomical telescopes can hardly be contemplated as this would involve interferometers of at least equal dimensions.

It was hoped that modification of Mr. Twyman's method, with an interferometer of usual size, could nevertheless be employed for large lenses or mirrors.

It was found, however, unless the two optical paths of the interferometers were equal, which would involve the presence of a second lens equal to the one to be corrected, that the circular interference bands are extremely small and difficult to observe.

The following simple, fairly direct method, obviates all these difficulties and has given excellent results.

A slit in the focus of the mirror or lens to be tested is illuminated by light from a Nernst glower, concentrated by means of a microscope objective and a total reflective prism. The light returns immediately above the prism forming an image of the slit which is viewed through a microscope with a $\frac{1}{4}$-inch objective.

A series of screens (an adjustable double slit would be much better) with two rectangular apertures are placed in succession in front of the lens or mirror to be tested; one of the apertures being central and the other at varying distances from the center.

The resulting diffraction figure will be a series of bands parallel with the slit, and the position of the central band (achromatic in white light) will remain constant if the adjustment is right and the mirror perfect.

The error in light waves will be half the observed error in fractions of the fringe-width.

The lens or mirror is rotated through the entire circumference, at intervals of 45 degrees or less, and the same operation repeated; and the results plotted on the corresponding chart, which gives accordingly the error in light-waves at every selected point of the surface.

This process applied to a 5-inch achromatic lens showed errors so small that artificial errors were introduced by placing in the path of the pencil a plane parallel plate which had been made roughly cylindrical by retouching locally.

The errors were then measured as described, and amounted to about seven-tenths of a light wave at the greatest. The corrector plate was again retouched by local polishing, and after a half dozen trials (time occupied being about six hours) the errors were reduced to the order of one- or two-hundredths of a light-wave; and the resulting image (which was badly astigmatic) was rendered practically perfect.

It is clear that such a process may be applied to even the largest astronomical mirrors or lenses, both in the original figuring and in the final correction; further, this final correction may be made upon the auxiliary plate, thus incurring no danger to the objective.

With evident modification the method applies to the correction of prisms and gratings. In the latter, however, since the light must be nearly homogeneous, there may not be sufficient intensity to observe the interference fringes under the high magnification required.

It may therefore be of advantage to apply the interferometer (replacing one of the mirrors by the grating) or even more simply, by observing the interference of the light reflected from a plane surface with that diffracted from the grating.

In either case, when the adjustment is perfect, the fringes are concentric circles—which remain constant when the eye or the observing telescope is moved about in any direction, if the grating is perfect; and if not, measurement of the diameters of the circles gives the error.

If, however, the difference of path in the interferometer is small, a curious singularity is presented. The interference fringes are no longer circles but complicated forms.—From the *Journal* of the Washington Academy of Sciences.

Draining the Zuider Zee

The announcement that the necessary authority has been given by the Dutch Parliament for the draining of the Zuider Zee probably brings ambitions which engineers have entertained for a very long period a stage nearer realization. It was in the closing years of the first half of the nineteenth century that Van Diggelen put forward proposals for drainage and reclamation which, in their main aspects, are not very different from those which are receiving attention today. The area with which it is proposed to deal is one of nearly 1,500 square miles, of which over 800 would be reclaimed and the remainder converted into a fresh water lake, thus providing a remedy for the present dearth in Holland of water supplies in summer. From the point of view of the engineer the reclamation, on which it is proposed to expend 15¾ million pounds, is a large-scale project of somewhat simple form.

The construction of a main embankment over 18 miles long, which it is estimated would occupy nine years in construction, would shut out the sea, and enable four areas extending over 500,000 acres to be set aside for reclamation. These would probably be available for occupation within twenty years, by which time the ordinary reclamation schemes in Holland, which have provided about 25,000 acres annually for a considerable period, will from natural causes have been discontinued. When the whole work has been completed 30 years hence, not only will a new province have been added to Holland, and the risk of floor damage from the Zuider Zee eliminated, but it will be possible to supply the brackish canal system with fresh water from the new lake.

An important railway connection across the new embankment between Friesland and North Holland is also included in the provisional plans. On the debit side of the account, regard must be had to the destruction of the Zuider Zee fisheries, but in comparison with the advantages to be derived from the reclamation these are of subsidiary importance.—Engineering Supplement of the *London Times*.

The Manufacture of Oleomargarine*

An Historical Review and Description of Modern Methods

A STEADY rise in the price of butter since the beginning of the war naturally causes an increased demand for butter substitutes. Under these circumstances it is of interest to examine the modern processes employed in the manufacture of oleomargarine. Curiously enough it was the Franco-Prussian War of 1870 which first brought this margarine or oleomargarine, as it is indifferently called, into prominence as a substitute for butter. It had been invented by the French scientist, Mége-Mouriés after the offering by the French Government in 1869 of a prize for a butter substitute which would be appetizing, wholesome and less liable to turn rancid than butter itself. Starting with the hypothesis that the butter in milk proceeds from the fatty tissue of the cow, Mége-Mouriés heated, at a temperature of 45° C., fresh beef fat freed from the surrounding tissues in an aqueous solution of sodium carbonate in the presence of the stomachs of sheep or swine. The action of the pepsin in the stomachs completely separated the fat from the remainder of the tissue; it was then drawn off and heated with a solution of two per cent ordinary salt to prevent rancidness; after being allowed to settle a yellow fat separated out, which was chilled to 22° C. The semi-solid mass resulting possessed the odor of butter and when pressed between heated plates it yielded from 50 to 60 per cent of a more fluid constituent, which was called oleomargarine, and sold under this name in Paris.

The inventor later improved this product by churning it with 10 per cent of cow's milk, and a small percentage of another ingredient (dilute cow's urine) until an emulsion was obtained. This was solidified, washed, salted, colored and sold as a butter substitute. It contained about 12½ per cent of water, and its melting point was from 17° to 20° C. In 1873 the Paris Council of Hygiene authorized its sale, but forbade it to be called butter. Since that time manufacturing processes have steadily improved. Many other oils and fats, vegetable as well as animal, are now used, and there has been great progress, both in the methods and the machines employed. It may be stated positively that the modern product made by an honest manufacturer is not only absolutely wholesome, but practically as digestible as butter. The fat is no longer digested artificially by pepsin since the butter aroma is now obtained by other means. Moreover, vegetable oils and fats have largely replaced the animal fats which were formerly exclusively used. The principal animal fats made use of are lard, oleo, stearine and what is called "First Juice," which is obtained by melting the best beef fat, sometimes frationed to furnish oleo stearine, either by hydraulic pressure at 48° C. employing cloth filters, or by fractional crystallization for several days at 28° C. By the first method a more fluid oleo is pressed out; in the second method the harder stearine crystallizes out. Professor Wiest, an American authority upon the subject, gives three formulas of general use in this country. The first, which furnishes the cheapest grade, consists of 495 pounds of oleo oil; 265 pounds of neutral lard, 315 pounds of cottonseed oil, 255 pounds of milk, 120 pounds of salt, 1¼ pounds of coloring matter. A medium grade consists of 315 pounds of oleo, 500 pounds of neutral lard, 280 pounds each of cream and milk, 120 pounds of salt, 1½ pounds of coloring matter. The best grade consists of 100 pounds oleo, 130 pounds of neutral lard, 95 pounds of butter, 32 pounds of salt, 1½ pounds of coloring matter. Since this last grade contains nearly one-quarter its weight of pure butter the price is of course correspondingly higher. It was formerly supposed that oleomargarine was less digestible and less nutritious than butter, especially when containing a considerable percentage of stearine. It is a fact that those fats whose melting point, like that of stearine, whose melting point is considerablly higher than the normal temperature of the body, are not readily digestible, thus more than 95 per cent of pure stearine passes through the alimentary canal without being digested. Of fats which melt at from 49° to 55° C., from 86 to 91 per cent remains unchanged, while fats which melt at or below 43° C. are almost entirely digested. Thus lard, bacon fat, goose grease and olive oil, all of which melt at a low temperature, lose less than 3 per cent. In almond oil there is a loss of 10.6 per cent; in mutton fat there is a loss from 7.4 per cent to 9.2 per cent.

But if fats with a high melting point, such as stearine, are mixed with the proper proportion of those with a low melting point, such as lard or olive oil, the resultant mixture becomes digestible because the melting point of the whole is lowered until it approximates that of butter. This is proved by the experiments of Luhrig, who found that the co-efficient of digestibility of butter was 97.86 and of oleomargarine 97.55. The solid oils used in oleomargarine making include those from cocoa and from palm kernels. The more fluid oils include cottonseed oil, peanut oil and oils pressed from Soya beans, from sesame, and even very recently from kapok, from Indian corn and from wheat. Modern refining processes have been so perfected that most of the vegetable oils mentioned above can now be obtained in a state of great purity almost entirely without either taste or odor. It is even possible to use whale oil or fish oil provided no deterioration has previously set in. Since the United States Federal law of 1886 practically no deleterious substitutes have been employed in this country in the manufacture of oleomargarine.

Undoubtedly the greatest advance in modern methods has been due to the introduction of hydrogenerated oils, and this feature will undoubtedly be increasingly developed in the near future. The fundamental principle of the hydrogenation of oils and fats is the transforming of comparatively cheap fluid oils, such as those from cottonseed, peanuts, etc., into more valuable solid fats by the action of hydrogen in the presence of a catalyser; for example the addition of one per cent of hydrogen to cottonseed oil gives a solid fat of about the consistency of lard. Since the processes of hydrogenation can be checked at any moment desired, it is thus possible to obtain from any given oil a fat of a melting point previously determined upon. One advantage of hydrogenated oils is that they have excellent keeping qualities. Knapp found no rancidness in specimens of such oils even after eighteen months, and the content of free acid (0.7 per cent calculated in oleic acid) remains practically constant. Brauner raises the objection that solidified oils increase the percentage of moisture in the margarine since they retain water in excess; but the English author, Mr. W. Clayton, finds this difficulty so easily overcome as to be practically negligible.

There has been some question as to the possible effect upon the health of the minute traces remaining of the metallic catalyser employed. Nickel is the catalyser most used, and most specimens of hardened oils contain traces of it, the amount appearing to depend upon the quantity of free acid in the oil, and the length of time the oil and the catalyser remain in contact. Goemer found in the specimen of hydrogenated oil of sesame containing 2½ per cent of fatty acid, an ash content of 0.10 per cent with 0.006 per cent of nickel oxide. Whale oil having 0.6 of fatty acid yielded 0.0045 per cent of nickel oxide. According to these figures a daily consumption of 100 grams of hardened oil would involve a maximum absorption of 0.6 milligram of nickel. Physiological experiments have proved that this quantity is quite harmless; Clayton states in fact that small daily doses of powdered nickel have no harmful influence upon the organism since 99.8 per cent of the metal is rapidly eliminated.

Milk is employed in the manufacture of oleomargarine for two reasons: First, as a basis for the development of the flavor, and second as an emulsifying agent. But milk is a highly favorable medium for micro-organisms since it contains all the elements essential for their rapid development; the micro-organisms commonly present in milk are lactic and butyric bacillae, various yeasts and molds and divers pathogenic microbes. To destroy the last milk is pasteurized by being heated for several minutes at a temperature of 82° C.

While pasteurization destroys certain useful ferments it cannot be dispensed with at present, since it destroys pathogenic germs without altering the milk so much as boiling does. Clayton believes however, that in the near future milk will be sterilized by electricity so as to leave the taste and other physical and chemical qualities unaltered. A method has already been patented for completely sterilizing milk by a high tension alternating current.

Another method by which milk can be sterilized at ordinary temperatures consists in the use of a large apparatus employing ultra-violet rays. Again, butter and some other fats have been sterilized by causing them to pass in a thin layer over an endless belt or drum revolving behind a series of lamps emitting ultra-violet rays. In the system now used the milk is thoroughly agitated and then poured, after being pasteurized, into a vertical refrigerator whence it falls into the fermentation vessels. By being cooled to 10° C. the development of bacteria is retarded, so that the action of any germs which have resisted pasteurization or been accidentally introduced later is reduced to a minimum.

The next step is the inoculation of the milk with germs adapted to develop an aroma similar to that of butter. To this end a pure culture of lactic bacillae is added, and the temperature brought to the degree favorable to their development; the lactic fermentation is continued until there is a degree of acidity which produces a rapid precipitation of curds. The milk is then cooled to prevent any other fermentation and kept at a low temperature till placed in the churns. While the aforesaid lactic fermentation gives the milk an acid taste and a pleasant aroma the true flavor of butter is still lacking, and will be until the proper bacterial action required to produce it is discovered. Clayton suggests that the solution may be found by a revival of Mége-Mouriés' experiments in the predigestion of the fats, or by a selective bacterial action on animal and vegetable fats. When this is accomplished water may be used as an emulsifying agent instead of milk.

When the milk has been prepared as above the proper mixture of various fats and oils is melted together in large vats heated by hot water or steam; when a uniform temperature is obtained the liquid is poured into the churns. Two types of these are in use. The older consists of a double boiler which can be heated by steam or cooled by water, and which is provided with paddles for agitating the contents. The two constituents are introduced separately into the churn, where contents are then agitated at a suitable temperature until a satisfactory emulsion is obtained; this emulsion is then discharged through a valve at the bottom of the churn upon an inclined glass trough where it immediately encounters a jet of ice water which strikes it with such force that it is instantly chilled into a solid mass which is immediately broken up into yellow "crystals" floating in the excess of water in the trough; these crystals are collected below in a wooden basket which allows the water to drain away.

The second type of churn, which is newer and preferable, is run by electricity and is of the continuous type. The milk and the liquid mixture of oils are conducted by separate tubes into a chamber kept at a carefully regulated temperature, where, after being mingled, they are completely emulsified by numerous paddles made to revolve rapidly by a motor. As soon as it is formed the emulsion is discharged into a glass trough, as above. Pumps of variable flow regulate the discharge of the milk and the oils, so as to form compounds which vary in the nature and proportions of the constituents employed. In some factories the product is not chilled by a jet of ice-water, but is solidified on a revolving drum kept at a low temperature the solid mass being automatically detached.

The object of the churning is to produce an emulsion resembling that found naturally in the case of cream in milk, in which the globules of fat persist as distinct particles in spite of their minute size, their diameter varying from 0.01 to 0.0016 millimeters.

Emulsions are of two types, according to which of the constituents is the "continuous" element and which the "dispersed" element. For the producton of concentrated emulsions a third agent is necessary. When the oil is desired to be the internal or dispersed element, the emulsifying agent must be capable of lowering the superficial tension of the external or continuous element; this agent may be viscous, like gylcerine, or "emulsoid," like gelatine. When the oily constituent is dispersed in the aqueous constituent a stable emulsion is readily obtained, the stability depending on the smallness of the oil globules, which is itself the result of the efficacy of the emulsifying apparatus. But when the watery element is to be dispersed in the oily portion a very unstable emulsion is secured, which tends to separate into two layers as soon as the churning ceases.

Milk is an admirable emulsifying agent, when the oily part is to be dispersed, because of the colloids it holds. An excellent emulsion is obtained by placing the whole of the milk in the churn, then adding the oily portion slowly while the churning motion is kept up continuously. The oil is thus concentrated, and later deposited in a homogeneous mass. In some factories however, the oil is placed in the churn first and the milk is then added. This produces an unstable system and such emulsions when solidified are uneven or "spotty" in texture because of the formation of curds. Apropos of this Clayton remarks that the continuous electric churn mentioned above gives a stable emulsion of the oil in the milk instead of an emulsion of the milk in the oil.

*In the preparation of this article we have been indebted to a report of an address delivered by Mr. Clayton before the Liverpool Section of the English Society of Industrial Chemistry and also to a pamphlet by Professor Wiest of the University of Vermont.

It is very important that the contents of the churn be kept at the proper temperature, which experience has shown to be from 25 to 35° C. A higher temperature curdles the milk, and the oloemargarine is therefore flecked with bits of caseine. Moreover, the aroma is affected by the temperature.

Many attempts have been made to increase the efficacy of the emulsifying agent by adding various colloids, including starch, gelatine, glycerine, yolks of eggs, lecithin compounds, and numerous patented substances. The hypothesis is that these colloids form a film or membrane around the globules of oil, thus preventing them from coalescing, and thereby increasing the stability of the emulsion. It is possible too that the electric charge of the particles may play an important part in preventing them from coalescing. Whatever be the explanation it has been proved in practice that the addition of 0.1 per cent of glycerine or of gelatine to the milk before churning will produce a better emulsion. When the product is solidified by the jet of ice water the glycerine or gelatine employed cannot be detected in the finished oleomargarine. Rapid cooling and crystallization tend to prevent separation, and also produce an absorption of minute particles of casein.

The yellow crystals obtained by the processes just described are next transferred to the ripening chamber, where the bacteria introduced by the milk can develop at the proper temperature. The duration of this maturing process depends on the quality of the margarine, the best animal fat margarines requiring a longer time. When the ripening process has been completed the crystals are subjected to centrifugation in revolving drums or passed between rollers in order to expel the excess of moisture, which must not exceed 16 per cent, and form them into a coherent mass. This mass is then transferred to mixers which contain rapidly revolving curved blades or paddes. By this means salt, coloring matter, an antiseptic, etc., can be intimately incorporated with the oleomargarine in about 35 seconds. Such admixtures are controlled by various laws in different countries. In England not more than 10 per cent of butter can be legally mixed with margarine. In this country artificial coloring is forbidden, so that some companies furnish a capsule of annatto with a print of oleomargarine, urging the consumer to incorporate it himself. The antiseptic used is boric acid, 0.5 per cent of this being sufficient to prevent the too great bacterial activity which produces acidity and rancidness.

Glycerine is sometimes added to give a more brilliant or glossy appearance to oleomargarine, and some producers consider that the texture is improved by the addition of from 0.5 per cent to 5 per cent of a wax, such as ceresine. Glucose is sometimes added, but Zoffmann has demonstrated that this is injurious, causing fermentation which produces carbon dioxide which bursts the wrappings. Clayton considers all such additions useless, finding that a good texture can be obtained by care in manufacture.

On analysis oleomargarine is easily distinguished from butter by the determination of the soluble and insoluble volatile fatty acids.

In some countries the law requires the addition of 10 per cent of oil of sesame to oleomargarine, since this enables a rapid and distinct test by color to be made.

It is characteristic of pure butter, when heated, to exhibit frothing and browning, whereas oleomargarine merely sputters and separates into oil and water. Hence some producers add substances which produce a frothing and browning like that of butter: among these are milk powder, casein, lecithin, yeast, malt extract, cholesterol, egg yolks, lactic acid, and various patented emulsions of lecithin and oil of sesame.

One of the most recent refinements in the technology of oleomargarine making is the use of artificial milk. The first steps in producing synthetic milk consist in making an emulsion of oil in water and adding lactose and suitable mineral substances to this emulsion; the finding of a substitute for the remaining element, the casein, so important in tissue building, long remained a stumbling block to the chemist. But this difficulty has recently been ingeniously overcome by the extraction of casein-like compounds from nuts by means of the action of alkaline substances, such as phosphates and carbonates. With these artificial milk has been prepared from which cream, oleomargarine, and cheese have been successfully prepared.

Clayton declares that this marks an advance as important as the introduction of solidified oils, and boldly looks forward to the day when the maker of artificial butter will be entirely independent of the milk man!

New Process for Manufacturing Filaments for Glow Lamps

THE new process is employed by the firm of Julius Pintsch, A. G., and is covered by German patents Nos. 291,994 and 293,236. Hitherto the filaments were made by hammering fine tungsten powder into small lumps at high temperatures, and then drawing or rolling the material into filaments, or, alternatively, by mixing tungsten powder with a binding material and forcing the mixture at high pressures through fine dies and sintering the filaments thus squirted. Filaments made by these methods consist of an assemblage of irregularly placed tungsten crystals, and it is owing to this structure that filaments are liable to break in consequence of alterations caused in their structure by the high temperature at which the filament is run. In the new process the filament is formed of a single long crystal, and the filaments have in consequence a much longer life.

Very finely divided tungstic acid (WO_3) is heated in a stream of hydrogen to remove the oxygen completely, and pure metallic tungsten falls out of the retort in the form of a grayish-black powder. To this is added a definite quantity of thorium oxide and quite a small quantity of colloidal binding material. The paste thus formed is squirted under high pressure through fine dies. The filaments thus obtained are gently dried, and are then drawn, eight at a time, through the forming apparatus, in which their structure is changed into that of a long endless crystal.

This apparatus consists of a glass cylinder, closed and airtight at its upper and lower ends, and containing a spiral of several turns of stout tungsten wire heated by an electric current. The filaments to be formed are drawn, at a uniform speed of about 2.5 metres per hour, through this spiral, and are in consequence exposed to a sudden temperature rise of 2,600° to 2,700° C. The tungsten spiral carries a current of 40 amperes at about 25 volts. A stream of reducing gas is maintained through the heating chamber. The speed at which the filaments are drawn through the chamber is of great importance. The filament contains a large number of small crystals that are turned during the process of crystallization into a definite direction. This change of structure is shown by micro-photographs from which it appears that the speed at which the filament moves must be smaller than the rate of crystallization in order that new particles of metal are brought into action at the correct moment to enable the continuous crystal to be further lengthened. If the speed is too quick breaks in the crystal appear. With a correct adjustment of speed single crystals of 25 m. length have been produced. The filaments thus produced are ready for use in lamps without further treatment. They are softer than drawn filaments at low temperatures and hard at high temperatures, and this property makes them particularly suitable for use in electric lamps. The tensile strength of the filament is 164 kg. sq. mm. Photographs of the wires bent into sharp loops show that no axial cracking takes place, as in an ordinary drawn filament. The end is quite uniform, and contrasts strongly with the ragged and splintered end of an ordinary drawn filament similarly cut. The fact that the new filament remains unaltered in structure after long periods of burning is shown by a test on a 30 c. p. lamp that had been burning 1,200 hours at a normal voltage, and several hours in addition at 10 per cent excess voltage. After this treatment the wire was still so strong that after breaking the bulb the lamp socket and the supports of the filament could be hung from the wire without breaking it. In contrast with this, the filament of an ordinary lamp would break into numberless small pieces after it had been exposed to such a length of burning.

A further advantage of the crystal filament lamps is shown by life tests of 1,000 to 1,200 hours in comparison with lamps of other types. In the latter the wires volatilize and a black deposit is formed on the interior of the glass bulb. With the crystal filament lamp no trace of such a deposit appears even if the lamp is burned at a voltage of 10 per cent above its rated voltage.—(*Elektrotechnische Zeitschrift* and O. Ely, *Zeitschrift des Vereines Deutscher Ingenieure.*)

Apos. Versus Achros.

To be able to alternate short and long tube work, to be enabled to use objectives corrected for the 250 M/M tube with 1.27 inch oculars, as well as those objectives corrected for the short tube with 23.7 oculars is a great advantage. Iv is not advisable to employ a 1.27 ocular on the short tube, and it is not profitable to use a 23.7 m/m ocular on the long tube, unless it may be that they are the best capped pattern of Watson's Holoscopic series. These are the very best all-round oculars I know of. With the eye-lens closed down they induce achromatic objectives to perform their best, and with it pulled out apochromatics work at their full capabilities. I mention this because a correspondent has asked me what are the best oculars to use with the 10-inch tubes. After a spell of short tube length in the D. P. H. I find it makes a very pleasing variation to remove the inner small tube and to substitute a piece of brass tubing 90 m/m in length, of sufficient diameter to carry a 1.4-inch ocular, and I have a series of adapters to accommodate the 1.27-inch and other gauges. After the somewhat restricted field with the short tube, the wide field of view and increased magnification made possible by the 10-inch tube is imposing. Then I use ordinary achromatic objectives and Baker and P. and L. Huyghenian oculars. To those who hunger after "apos." and feel sad because they are beyond the reach of their pockets, let me say, good achromats and good Huyghenian oculars want a lot of beating. I had a Reichert 1-12-inch o. i. apo., N. A. 1.35, recently to try, and I found absorbment in comparing it with my Baker 1-12-inch o. i. achro., N. A. 1.30. Of course, the apo. gave a brighter and more refined presentment of the objects I tried it upon, but the achro. came so near it that I valued it all the more highly. One evening I used the eyes of a scientific lady and tried them on Aulacodiscus orientalis. Very accurately she described what the apo. showed and was charmed with the picture it made. When I substituted the achro. she said, "There is some falling-off in crispness and of brightness," but when I interposed one of my light collecting and filtering globes she said that the difference between the two objectives was much less appreciable and pretty well negligible. The only apos. I ever really coveted were Watson's new 1-12-inch and the Zeiss ½-inch. I often say, from an aesthetic point of view, "Once an apochromatist, always one," and that is why I shrink from introducing them into my collection. A correspondent bewails the fact that the back lens of his 1-12-inch apo. shows signs of deterioration. For some cause or other this often happens. Renovation seems impossible. Renewal is the only remedy.—*The English Mechanic.*

Origin of Blackdamp

IN a paper before the Institution of Mining Engineers, Mr. J. Ivon Graham discussed the origin of blackdamp, pointing out that a knowledge of the exact composition of the blackdamp existing normally in a pit is essential if, by means of the chemical analysis of mine-air samples, it is attempted to discover the presence of heatings or trace their history.

Pure blackdamp, free from admixture of air, is a mixture of carbon dioxide and nitrogen, and Dr. Haldane and Mr. W. N. Atkinson came to the conclusion that it is not given off by the coal like firedamp, but is the residual gas left on the oxidation of the coal by air. The variation in its composition, however, makes it probable that different sources are responsible for its production. The carbon dioxide may arise from the breathing of men and animals and the burning of lamps, may be a constituent of the gases evolved from the coal during mining, may be the result of the oxidation of coal or other carbonaceous materials, or of the oxidation and decay of timber, or may be caused by the action of acid pit waters on carbonates. Nitrogen similarly may arise from the withdrawal of the oxygen of the air by the processes just mentioned, or it may be evolved from coal.

The author concluded that should the blackdamp occur solely from the oxidation of coal its composition will probably be 5 per cent carbon dioxide, 94 to 94.5 per cent nitrogen, and possibly ½ to 1 per cent of carbon monoxide, the question of the production of which is being further investigated. In blackdamp from rotting timber the proportion of carbon dioxide may amount to as much as 20 per cent, while in pits where acid water is largely produced, owing to the oxidation of iron pyrites, the resulting black damp may contain about 12 per cent of carbon dioxide. Coal seams which are liable to give off carbon dioxide in large quantities along with fire damp or by itself will also influence the composition of the blackdamp.—Engineering Supplement of the *London Times.*

Destroying Aphides and other Garden Operations

SOME years ago I was told of the simple plan of dipping the tender ends of the long rose shoots on which aphides swarm in a can of hot water, *i. e.*, so hot as to be rather hot, but not scalding to the hands, and evidently less hot than that which may be used with a syringe. The aphides come off at once and go to the bottom, as also do secretive caterpillars and the unpleasant cuckoo-spit insects, and these last go on blowing shiny bubbles from the bottom of the basin for a time if the water is not too hot. The tender rose-shoots are not damaged nor are the buds; but it is easy to have the water too hot, in which case the first shoots treated may be damaged. Then there is a peculiar satisfaction in turning the tables and watering the rose trees with the mixture of warm water and dead insects so that the trees may feed upon them! Another garden operation which was told to me I have found most effective, but it is hardly one to practice at these times. To weed garden paths, go over them with a blowlamp. Everything is killed, seeds and all, whereas by the usual plan, which is much more laborious, all the seeds are most effectively sown so as to produce a better crop next time.—*The English Mechanic.*

Roughing out wooden sabots in France

Preparing the uppers for sabot-galoches

Shoes of the French Soldier

THE French military administration has been obliged to install properly equipped stations in the rest camps near the front, where the footwear not too badly worn might be repaired. Here the brave shoemaker, serving in the territorials, recognizes again the nails, the leather and the soles which are salvaged from the equipment of his companions in arms.

When army shoes are about used up they are collected at a point in the rear, where they arrive by the wagon load. After they have been cleaned they are roughly sorted according to size by means of the gage illustrated; and if worth the trouble they are repaired and returned for distribution, otherwise they are definitely discarded. But the rain transforms the trenches into veritable sewers, so that it is necessary for soldiers, when they go into the front lines, to have water-proof boots to keep their feet and legs at least partly dry. The command cannot dream of giving good leather shoes to the poilus for such rough service, this would be too wasteful. So ingenuity has been called upon in the manufacture of shoes from less costly materials.

The trench shoes now specified for the French army consist of a sole of wood with uppers of cloth or canvas, water-proofed. These are so made that their weight is a minimum, while they can be repaired cheaply.

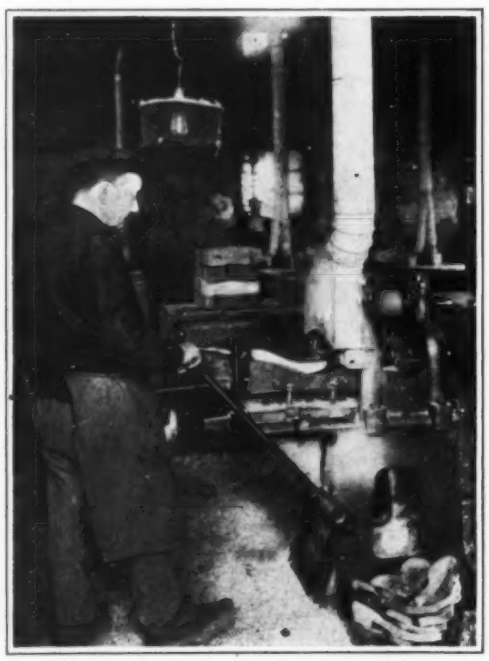
The manufacture of the sole constitutes the most original part of the process of shoe-making for the soldier in the trenches, as practiced in the Vosges. Here the pieces of wood, mostly beech and birch, are received; they are trimmed with a band-saw into boards of various thickness, according to the size of the soles to be made. Then, with molds representing the outlines of a rough sole, a pattern is traced on these slabs. The molds here used naturally vary also according to sizes, which run by centimeters; and there are also four shapes, corresponding to four kinds of soles.

First there is the *galoche*, properly so-called, otherwise known as the *sabotine*. This has heels cut from wood, with only the forward part covered with hide; soldiers on rest at the rear wear shoes with such soles. Then we have the clog or *socque*, much like the *sabotine*, but lower and lighter. Also there is the *bois plat*, with full heel, covered with hide before and behind; our officers do not despise to wear in camp practical shoes thus made. Finally there is the *semelle fourres*, a sort of flat wooden affair with grooves which will take a detachable upper of cloth, thus being converted into a trench shoe.

Regardless of which kind is being made, the sole is sawed in the desired curve with a band saw, following the lines of the pattern which has been traced on the block. Then after the bottom has been planed off with a specially constructed machine, the *raboteuse*, the sole goes to the spindles where are fashioned the heel and the front part. These spindles consist of two vertical shafts having a velocity of 3,000 revolutions per minute and carrying chucks on which are mounted the blades to shape the heel and toe. These shafts turn in opposite directions in order to avoid chipping and tearing the wood.

Next the soles are fastened upon the *porte-gabarit*, a sort of steel press equipped with a piece of sheet iron 4 or 5 millimeters thick, which the workman holds upon the table and pushes against the guide placed below the chuck. These sheets of iron have the shape of the heel or of the forward part of the sole, and it is only necessary to turn them over to make a right or a left with the same mold.

The rough sole thus obtained passes to the machine which planes off the inside. The business end of this machine comprises a circular iron plate with two blades. The sole is held on a movable carriage against these, which the workman guides by means of two levers. Then for *sabotines* and *socques* after having shaped the inside of the sole, the heel is hollowed out by a bit carried at the upper end of a shaft. For this work, the sole is mounted upon a carriage bearing a last, which holds the piece against the tool. The workman gives a forward and backward motion to this carriage, and at each stroke the bit descends and takes a bite from the wood, until the buttress of the heel is formed. This operation is a very delicate one because of the risk of chipping entailed by cutting across the grain.



Shaping soles for wooden shoes by machinery

The sole is now ready for lapping, which consists in lifting the two sharp edges of the buttress with a special knife, and using the scraping knife upon the inner side of the heel. Then we pass to another machine designed to cut the grooves necessary for the nailing on of the uppers of cloth or hide. With this groove the soles take on their final form; it remains only to polish them. This is done by means of sand-paper glued upon an endless belt of leather. After this the polished soles are heaped upon trucks and placed in a hot room to dry for a few hours.

The completed and dried soles are now despatched to the assembling headquarters. Here soldiers of the army reserve nail the waterproofed cloth or canvass upon the edges of the soles. The completed shoes then undergo a second waterproofing in a hot bath of linseed oil, an operation intended to close the holes made by the needles in sewing.

With the footwear thus constructed the poilus can face the most juicy communication passage, or the mud of the worst trench in Flanders or on the Somme. For by putting on these sabots in the rest stations, they afford the wet campaign shoes time to dry. Most of these sabots are made by machine in big factories, but a certain number of army shoemakers work also in the forests of France to supply the brave defenders of the country with dry footwear.

A New Type of Iron-Concrete Arch

DURING the months of August-September, 1914, a number of masonry bridges were destroyed on the Chemins de fer de l'Est. On the retreat of the Germans, it became necessary to restore these structures with the least possible delay. The plan adopted was to bridge the gap with rails bent to the curvature of the arch. These rails served in the first place, as centering for the deposition of the concrete with which the arch ring was completed, but being embedded in this concrete, they constituted, at the same time, a permanent reinforcement. The results proved so satisfactory that the French Government sanctioned the building at Melun of an experimental arch, constructed on the same general system in order to subject it to a thorough test. A description of this arch is given by M. Frontard in a recent issue of the *Annales des Pont et Chaussées*. This experimental arch had a span of 25 meters and a rise of 2 meters only. Its thickness was 0.6 meters, and width 1.8 meters. The metal work consisted of three arched frames, 0.45 meters deep each, built up of four 70 mm. by 70mm. by 7 mm. angles, latticed with flats, 50 mm. by 6mm. These ribs were spaced at 70 cm. centers, and were cross-connected by angles. This light-steel framework was then filled in with concrete. The shuttering used was supported from the steelwork, and no other centering was required. The concrete consisted of 0.800 cub. m. of gravel, 0.400 cub. m. of coarse sand, and 400 kg. of portland cement. It was deposited in 20 sections, each to the full depth of the arch ring. In the first stage, six of these sections were cast, equally distributed over the span. When these were set, an additional eight sections were deposited, and the arch was then completed by filling the remaining gaps. Care was taken throughout this work to distribute the load over the metal-work as uniformly as possible. Until the completion of the concreting, the whole of the load was carried by the steel arch, which was in this way given an initial compression, which it retained permanently. As in the completed bridge the function of the steel is to take the tensile stresses due to inequalities in the loading, this plan of giving it an initial compression adds to the security of the structure. After completion, the arch was very thoroughly tested. This was done by piling on to it old paving blocks to a depth sufficient to impose a load of 1,860 kg. per sq. m. In the first test, this load was applied to one half the arch only. In the second test, the central portion of the arch was loaded, the load extending on each side to a distance of one-quarter span from the crown. Finally, the whole of the arch was loaded. The load imposed was about three times that specified in the official regulations for highway bridges, and this load was carried without the development anywhere of any sign of weakness. Careful arrangements were made for measuring the deformation of the structure and the observations taken are said to have been in satisfactory agreement with the calculated values.—*Engineering*.

A Test for Damaged Wheat

IT has been discovered that an effective indication of the contamination or deterioration of wheat is afforded by the ammonium content of the extract obtained by soaking the wheat in water. Thus the damaged samples examined were found to yield from 8 to 15 times as much ammonia as the clean wheats.

Making sabot-galosches for the French armies

Sorting worn army shoes according to size

The Large Power Station

Problems of Control of Electric Generating Stations

A PAPER presented before the Institution of Electrical Engineers by Mr. E. B. Wedmore was concerned with the problems of controlling large amounts of power that arise in consequence of the increasing size of electric generating stations, and discussed the methods of employing reactance in order to maintain continuity of supply and to protect the plant.

He pointed out that the larger stations and the linking together of existing plants required in view of the increasing use of electrical energy and its economical production involve something more than the use of larger units and the adding of unit to unit. New conditions are reached. Factors which were negligible in smaller aggregations of plant become serious and limiting features. The forces accompanying a disturbance are increased, and the total number of disturbances to which a system is subjected increases automatically with each extension; thus there are introduced new problems in the design of individual parts of the plant and in the arrangement of them.

CONDITIONS IN DISTRIBUTING SYSTEM

There are no insurmountable difficulties in the design of larger machines, heavier cables, and switchgear all able to cope with larger forces than have yet been met with, but the limiting features are to be looked for not only in the generating station but in the distributing system. Stations and networks spread over a large area may be coupled together without necessarily seriously modifying the forces to be dealt with at any point, but a striking characteristic of developments now in prospect in the principal industrial areas is the increased concentration of large amounts of power in small areas. The size of a generating station may be doubled with advantages in economy and without excessive expenditure on switchgear to take care of the conditions in the station itself; but for every machine, switch, and conductor in the main station there are large numbers of smaller machines, switches, and conductors in the distribution system, and if these also are subjected to increased forces a very heavy expenditure may be necessary to ensure satisfactory service. Not only is this true as applied to an individual town, but similar conditions may arise where a large bulk supply scheme is devised and a number of existing small plants are linked up to a common source.

PROSPECTIVE DEVELOPMENT

The report of the Coal Conservation Sub-Committee discussed the design and use of alternating current generators in units up to 50,000 h.p. and over. In this country machines in sizes up to 40,000 k.v.a. are already being built, and even larger ones in the United States. Stations have been designed for an ultimate output exceeding 200,000 k.v.a., and this figure has been approached in installations already in operation. It is thought, however, that in this country the requirements will be met for some years to come by stations not greatly exceeding 100,000 k.v.a., and mostly with generating units not exceeding 20,000 to 30,000 k.v.a. maximum rating. Not only do difficulties of water-supply tend to limit the size of stations, but in areas where 200,000 k.v.a. can be utilized economy in distribution will generally be obtained by means of two 100,000 k.v.a. stations, the transport of coal and water being more economical under suitable conditions than electric transmission.

The general use of generator units of the order of 50,000 k v.a. output would throw excessive stresses on distribution apparatus and small plant generally unless special precautions are taken. There are, however, other considerations also which point to the use of smaller units. In the first place the question of spare plant has to be considered. A large unit may fail at a time when another similar unit is temporarily out of commission, pointing to the provision of two spares of the largest size. This is increasingly important on large systems where more and more services become dependent upon the electric supply, and where the load factor is high. The time required to restore to service units of this magnitude that may have been put out of commission is much greater than in the case of units with which most engineers are familiar. This and the fact that such large units could not be employed economically except on large interconnected systems with a total output greatly exceeding 100,000 k.v.a., all supports the contention for the general use of machines of 20,000 to 30,000 k.v.a. These machines, generating at about 6,000 volts, will be used mostly with transformers stepping up to 20,000 or 30,000 volts for transmission. Generally the machine and transformer bank will form one unit, all switching being carried out on the high-voltage side. There is likely to be an increasing use of overhead lines for distribution of small amounts of power over long areas, but large amounts of power will be distributed through underground cables, on account both of increased freedom from disturbance and of convenience in densely populated areas.

Finishing the wooden soles of sabot-galosches

LIMITATION OF DISTURBANCES

Means must be found to ensure maintenance of voltage at all parts of the system and to prevent the disturbance of running machinery; and also to limit the power which can be concentrated at any point on the occurrence of a fault, without excessive expenditure on the construction of individual pieces of apparatus. That special measures are necessary is clear from the fact that if practice hitherto prevailing is followed in the extension of existing plaints, switchgear on consumers' premises may be subjected to forces comparable with those now met with in large generating stations. By suitable proportioning of the different parts of the system and the employment of quick-acting selective protective apparatus the disturbances can be both localized and limited.

The crude method of sectionalizing the plant reduces the conditions to what they would be on small plants, and has been practised extensively. The object, however, of large combinations of generating plant is economy in production, and this is obtained by an interchange of energy between the different sections, which enables larger and more economical units to be employed, reduces the number of spare machines necessary, and improves the load factor. Thus interchange of power has to be provided for. On a large plant the easier conditions of small plants can be regained to a considerable extent by dividing the system into sections and paralleling these through reactances. This will admit of the interchange of energy for purposes of economy, and at the same time limit both the interchange of energy during severe faults and the disturbance of sound sections.

The employment of reactances for interconnecting, whether between busbar sections in an individual station, in trunk mains between busbars in different stations, or in interconnectors between adjacent parts of the distributing system, has the distinctive merit that, so placed, they carry only that portion of the load being transferred from section to section, and thus waste a minimum of energy and do not interfere with regulation. Reactance may also be employed in series in any part of the system, but, so used, the reactance will have to carry the total load fed to that part. Wherever employed the reactance limits the disturbance in all parts of the system beyond it and tends to isolate the disturbance from all parts nearer to the source of supply. The desired results will be most economically obtained when interconnecting reactances are employed, but if the inherent reactance of the circuits, transformers, etc., is sufficient adequately to localize the disturbance, the employment of a certain amount of artificial reactance in series will be necessary also.—*London Times Engineering Supplement.*

Manufacture of Paper-pulp, etc., from Dead Leaves

THE process is simple, rapid, and not costly. The leaves are crushed and separated into two parts, *i. e.*, the veins and ribs, and a powder. The veins and ribs, which yield the paper pulp, are submitted to a rapid washing with alkali, followed by washing with water and bleaching, and then made into pulp. The powder, which has a feeding value almost equal to that of hay, may be mixed with molasses and compressed into cakes and fed to animals. An alternative use for the powder is to submit it to dry distillation, when it yields a relatively pure, porous carbon, with a high calorific value, tar, acetone and pyroligneous acid. In this way 1,000 kilos. of leaves yields 250 kilos. of paper pulp and 500 kilos. of fodder or 200 kilos. of carbon, 30 kilos. of tar, 1 kilo. of pyroligneous acid, and 600 grms. of acetone.—Note in *J. Soc. Chem. Ind.* on an article by K. BRAMSON in *Comptes Rendus.*

The International Bureau of Weights and Measures*

DURING the months immediately ahead of us millions of American citizens will acquire a practical knowledge of the metric system, either as soldiers on the Western Front, or as members of the great industrial army furnishing equipment and supplies to our own troops and those of our Allies. Already there has been a considerable amount of propaganda for the replacement of the English weights and measures for those based on the meter and generally used in Europe. It is only fair to state that some eminent authorities oppose this change. Under the circumstances the following account of the International Bureau of Weights and Measures which, we abstract from a late number of *La Nature* (Paris) is of peculiar interest.

Motives for its Creation.—The program of this Bureau was at first very restricted. Its *raison d' être*, and the object of the association of the Governments which attended the Convention of the Meter on May 20, 1875, was to compare lengths and masses with the highest possible degree of precision in order to assure throughout the entire world perfect uniformity in the use of metric measures.

Situation of the International Bureau.—The execution of exact measurements demands an absolutely quiet locality, free from the disturbances of earth, air, and buildings which are the inevitable result of the traffic of cities. The laboratories themselves must be spacious and sheltered from rapid variations of temperature. These are the reasons which led to the installation of the Bureau within the area of the *Pavillon du Breteuil*, in the Park of St. Cloud, placed at the disposal of the Convention of the Meter by the courtesy of France. The next step was to erect a building whose principal chambers should be surrounded on all sides by a multiple envelop which permits external variations of temperature to penetrate so slowly that the diurnal period is quite insensible within.

Complexity of Precise Measurements.—A first question presents itself: Why is it necessary, for operations so simple as the comparison of a limited number of standards of length or of mass, to create a special institute whose program of work is, so to say, continuous? The answer lies in the aphorism that to attain ten fold percision a hundredfold labor is required, and also to change methods when the exigencies of progress demand it.

A single example will make clear the complexity of metrologic problems of the greatest apparent simplicity.

A very good balance may enable us to attain a precision of the order of a hundreth of a milligram in a kilogram, or one one hundred-millionth of the quantity measured. But if we compare, in the air, a kilogram of platinum with a kilogram of quartz, the difference of thrust between these two masses of matter is of the order of 400 milligrams, or 40,000 times the precision of the weighing. When we attempt to weigh objects in a vacuum, if we are to attain any such accuracy as this, it is necessary that we are able to calculate the thrust even more closely—say with no greater error than 1 in 100,000. Therefrom results the necessity of knowing the density of the air with this approximation, that is, the barometric pressure with a precision of the order of a hundredth of a millimeter, the temperature of the air to within a few thousandths of a degree, etc. The knowledge of the volume of the two bodies must comprise a corresponding precision, whence the need of a hyrdostatic weighing and of its reduction based upon the measurement of the temperature of the water and the establishment of its formula of dilatation. In short, this simple operation consisting in the comparison of a kilogram of platinum with a kilogram of quartz demands extension to the supreme limit of possible precision in the investigation of the elements of reduction without whose possession the principal operation would lead to a wholly illusory result.

It is problems involving such minute detail as this which the Bureau of Weights and Measures has been called upon to attack since its creation. I will not say that it has solved them, since metrology is a perpetual rebeginning; but it has made important progress in more than one of them.

Thermometer and Barometer.—The example just given shows the necessity, before undertaking any piece of metrologic research, of fixing perfectly the values of the independent variables, pressure and temperature, which enter into all reductions. Sustained attention has therefore been given in the International Bureau to the perfecting of the thermometers and barometers, for which Regnault's results, become insufficient at the end of thirty years, had been relied upon. These labors of the Bureau are today well known and we will not linger over them. It is enough to say that from thereon dates the complete rehabilitation of the mercury thermometer, the precious intermediary for obtaining the normal scale, which, according to the decision arrived at in 1889, by the first General Conference of Weights and Measures, is that furnished by the hydrogen thermometer under constant volume, and under the pressure of one m. of mercury at 0°.

Measurements of Masses.—A commission composed of Dumas, Mouchez, Sainte-Claire Deville, Broch, and Stas, was charged with realizing the report of the mass of the kilogram of the Archives in agglomerated platinum upon the new international kilogram, made of iridioplatinum, the admirable alloy created by Sainte-Claire Deville. By closer and closer sucessive rubbings, the new kilogram was approximated to the old one by abrading, and when it became impossible to detect the difference the operation was stopped.

Under the supervision of the French Section of the International Commission of the Meter a series of kilograms were adjusted as closely as possible to the new standard, and then comparisons between them were undertaken.

For, in a precise determination, we are not content with comparing a copy with the fundamental standard; the copies are also compared with each other, in more or less extensive groups, in such manner as to establish multiple controls and direct connections between the copies.

The kilograms, to the number of 42, were placed in a table comprising 7 lines and 6 columns. All the standards inscribed in each line were compared with each other, and in the same way those comprised in each column. All were compared with the international kilogram. When this work was completed it could be affirmed that the value of each of them was known, with reference to that of the international kilogram, with a precision exceeding a hundredth of a milligram, that is to say, to at least one hundred-millionth of the quantity measured.

We are aware, however, how fallacious the calculation of precisions is, with what circumspection we must accept the result of calculation applied to measurements. In the present instance a remote verification came to corroborate the first conclusions. The International Bureau has been charged, in fact, not only with furnishing the values of the national standards, but also with verifying them from time to time. A first control of the kilograms has been accomplished. Apart from one of them, which very frequently employed, had probably suffered wear beforehand, and three others, visibly damaged by accident, the old values were refound, for the most part, with variations less than the hundredth of a milligram. It is within so close an approximation as this, therefore, that the International Bureau has been able to accomplish, for the entire world, the uniformity of the measures of mass.

But, it will be asked, how are the balances made which permit the attainment of such precision? For the hundred millionth in the result implies the same relative equality in the two arms of a balance beam, *i. e.*, in the position of the central blade, an accuracy of the order of the thousandth of a micron, which a difference of a thousandth of a degree in the temperature of the two arms of the balance would render useless.

The principle is that of the exchange of the weights upon the pans, which eliminates the difference of the two arms, an exchange made at a distance, in order that the radiation from the operator may not disturb the temperature. The readings are made by the aid of a telescope sighting the image of a scale reflected in a mirror borne by the balance beam. The difference between the weights compared is therefore primitively expressed in function of the unit of this scale. This is transformed into units of mass by adding to one arm of the balance beam, a tiny additional weight of 1 milligram or ½ milligram. But such a weight is hard to handle, especially at a distance. We therefore place simultaneously upon the two arms two weights of approximately 100 milligrams, differing from each other by the quantity which is to remain in excess. This addition can be made while the balance oscillates, in such wise as to avoid the losses of time and the disturbances involved in each arresting of the balance.

Lengths.—The comparison of lengths is much more diverse than that of masses; it comprises a much larger number of distinct problems, and the arrangements which apply to one of them are rarely adapted to the solution of another.

Cathetometers, spherometers, and various micrometers operating by screw or by lever are instruments of current use in laboratories and workshops. They are equally used in metrologic institutes; but in the latter, precise measurements are executed by the aid of special apparatus, comparators.

A comparator is applied either to distances along a line, or to distances between points, or in passing from one system to the other. For the first an essential organ is the ensemble formed by two micrometric microscopes, definitely fixed on posts or supported by a beam upon which they are momentarily clamped in such a manner as to constitute a fixed ensemble for the duration of the operation.

The two lengths which it is desired to compare are brought successively under the two microscopes, either by a transverse displacement, the two standards being placed side by side, or by a longitudinal sliding, the two lengths forming a continuation.

The microscopes possess a general magnification comprised between 50 and 100. The thread of the micrometers is usually adjusted so as to correspond to the tenth of a millimeter, measured upon the object observed. Thus the hundredths of the revolution, the interval of the division of the drum, is equivalent to the micron, the thousandth of a millimeter; the tenth of the interval being read directly, it is the tenth of the micron which is inscribed as the unit of observation. At least, these are the most frequent conditions.

Measurement of Expansion.—In the measuring of dilatations there are two classic processes: that of the comparator and the process originated by Fizeau, and put in operation in the dilatometer which bears his name. The first is applied to bars of considerable length, one meter in general; the second, thanks to the extreme delicacy of the phenomenon upon which it is based, which is the displacement of the rings of Newton in a thin stratum of air, yields very precise results when applied to gauges whose dimension is of the order of the centimeter.

The measurement of expansion has been one of the most continuous tasks of the International Bureau, not only by reason of the necessity of knowing perfectly the formula of dilatation of all the standards issued by the Bureau, but also because this measure has been employed as a method of investigation of metals or alloys, whose results have justified the time and the effort devoted to this study. It is enough to recall that the application of the nickel steels in the industries and the arts of precision have had for their origin the work accomplished by the International Bureau.

Geodetic Comparator.—The revision of the value of the standards employed in geodesy was one of the essential motives in the creation of the International Bureau; hence it was planned, in the first years of its existence, to construct suitable apparatus for carrying out this part of its program.

The measurement of terrestrial bases utilizes standards of the greatest length which can be handled. After the standards of two fathoms, such as those constructed by Borda and Lavoisier for the immortal work of Delambre and Méchain, the next step was to those of four meters, differing slightly from them by excess, and it was in view of their determination that the geodetic comparator was constructed. This instrument is well enough defined by characterizing it as an ensemble of four dilatation comparators placed end to end.

Five microscopes aligned, leaving intervals between them of one meter[1], point toward the same horizontal line, which may become that of the standard which is being studied. The latter is enclosed in a trough side by side with another similar standard, or with a standard of one meter, which is placed successively opposite the four meters of the geodetic standard. The corresponding microscopes then serve to make a report of the lengths, meter by meter. By way of verification, we generally compare with each other several geodetic standards which have been determined individually.

The majority of geodetic standards in use in the world have been studied by means of this comparator: not only those of four meters, but also those of double-fathoms, to which were added appendices in contact with their extremities (the old standards were all undivided) in such a manner as to bring them to the length of four meters. The contact pieces, brought into contact with each other, were determined in another operation. Standards of 10 English feet belonging to the Geodetic Services of India and the Cape, have likewise been studied. And from this whole ensemble of measures there has resulted the unification of the data relating to the measurement of the earth.

Universal Comparator.—In the International Bureau the meter is a length which is given the preference, but not exclusively. For measuring other lengths it is necessary to possess instruments whose microscopes are capable of being displaced. Such is the universal comparator, provided with two microscopes, mounted on carriages borne by a double steel beam, placed on stone posts.

There are benches to hold the pieces to be compared governed by means of regulation and of displacement,

*From *La Nature*.

[1] In a recent modification of the comparator the pairs of end microscopes were mounted on beams in order to be able to take variable distances.

whose handles are controlled by the operator. The displacements may be either transversal or longitudinal, for the reasons indicated.

In its ordinary form the universal comparator has served to establish the value of the subdivisions of the meter, and to provide precise standards of the decimeter, the centimeter, the millimeter, or any intermediate length. The problem seemed simple, but everything becomes complicated when a high degree of precision is sought. Moreover the necessity for a very minute study of the question proceeds from the following fact, well known by mechanics of precision for the last 40 years: when a millimeter standard was asked for at Paris, the purveyor offered, at choice, the copy of that by Brunner or of that by Froment. They differed perceptibly, and no one could say which was the nearest right.

Thanks to the measurements made by the universal comparator of the International Bureau, thousands of lengths less than a meter have been distributed whose value is known approximately to a few tenths of a micron. But it is also by the aid of this instrument that we have determined the length of the gravity pendulums, the metric value of the fathom of Peru, and of the so-called fathom of Bessel, standards which have played a part of the highest importance in the old geodesy. The determinations of them which have been made by M. Benoit, have caused the disappearance at the boundaries of divergences which had previously remained inexplicable. Other measurements to which M. Benoit has likewise devoted his entire attention, have given the legal ratio between the yard and the meter, a ratio in regard to which there is at present a reform imminent in the British measures, and whose numeric value is as follows:

1 yard = 0.9143992 meters.

1 meter = 1.0936143 yards.

Undivided Standards.—While undivided standards had been increasingly abandoned as scientific standards at the period when the researches of the International Bureau began, they reappeared 20 years after to do service in the mechanical industries of precision. The Technical Section of the Artillery, charged with the manufacture of interchangeable pieces, created a complete service for the establishment of standards and addressed itself to the International Bureau to obtain types derived from the international meter, which it sufficed to copy later. This work was entrusted to me, and in connection with another piece of research I had joined to the universal comparator a special support designed to facilitate the execution of this work. The support comprises two grooves placed in the same alignment, in which can be placed the rules serving to come in contact with the piece to be measured. The extremities of these values are spherical; they themselves are grooved in such a manner as to show the plane of the center of the spheres, and where the marks of division are placed.

The contact pieces, stretched by constant weights, are first brought together and the distance of the division marks compared to a known length, taken upon a divided ruler; then the standard to be measured is intercalated, and the same operation is repeated. The difference of length found gives the value of the standard.

The possession of undivided standards of well known value, permits this reproduction by processes not comprising the complications necessitated by the passage from one system to another. This reproduction is made by the aid of the ingenious automatic comparator of Col. Hartman. A description of it has already been given in *La Nature*.[2] The measurement of undivided lengths elaborated in metrologic institutes has spread among workshops, for which there have been created very precise machines serving various purposes. We refer to a previous article for the descriptions of their principle.[3]

The Length of Luminous Waves.—An atom of matter, self vibrant with a constancy not attained by the best timepeice, sends into space luminous waves whose length, in well determined conditions of propagation, is equally constant. The knowledge of one of these lengths in absolute value is fundamental in all spectroscopy; it is equally so in metrology, since the luminous waves, manifested by fringes of interference, are directly utilized as micrometers in a large number of problems.

In fine, if we can accept the constancy of vibration of atoms as not merely very perfect, but absolute, we can make the length of waves an eternal mark of the unit of length. It is under this form that we today represent the natural division of lengths which was formerly referred either to the dimensions of the earth or to the length of a pendulum beating seconds.

It is the task of the International Bureau to determine in absolute value certain lengths of luminous waves among those which best lend themselves to precise measurements.

We have told elsewhere[4] how, making use of the beautiful methods invented by himself, A. Michelson, the eminent American savant, succeeded, with the collaboration of J. René Benoît, in fixing, with a precision which was estimated at that time to be 50 times as great as that of the best previous measurement, the lengths of the waves emitted by the cadmium lamp. The work was resumed 15 years later by Benoît, Fabry, and Perot, utilizing a physical method whose fundamental peinciple is that of the first, but which differs from it in the application so greatly that it has led to a new metrologic application.

An exposition of this extremely important work can not be made in a very limited amount of space; we hope to take it up later. It is enough to say that the result accords with that of the first investigation within approximately a ten-millionth, a closer agreement than we could have foreseen from the precision attributed to the first investigation, favored, it appears, by a little bit of luck. But let us not forget that in metrology luck specially favors those who deserve it.

Researches on the Alloys.—The perfecting of the construction of the standards themselves did not figure in the original program of the International Bureau, but was imposed by the logic of things. This research was fruitful beyond our hopes. The discovery of *invar* whose applications are today so numerous, was the essential point of it but not the sole result, for the anomaly upon which this curious alloy depends is extensive and diverse, and the solution of many scientific or industrial problems is found therein.

Horlogy has benefited by it largely; it has brought very considerable elements of economy to the manufacture of incandescent lamps, and we have not yet come to the end of the application of this nickel steel. Some day a new exposition of this question, frequently broached in *Le Nature*, will demonstrate its diversity. Treated here, it would become, like the preceding, too encroaching for a general article. We desired to give only an outline here; the abundance of the material has already extended it too greatly.—CH.-ED. GUILLAUME, Director of the International Bureau of Weights and Measures.

[2] *La Nature*, No. 1284, Jan. 8, 1898.

[3] *La Nature*, No. 1970, Feb. 25, 1911.

[4] *La Nature*, No. 1174, Nov. 25, 1895.

Refractoriness Under Load

A REPORT of the effect of load on the refractoriness of firebricks, etc., by Dr. J. W. Mellor and Mr. W. Emery, was presented on behalf of the Refractory Materials Research Committee. This committee stated that during the year special bricks prepared for investigation purposes were tested for refractoriness, contraction, and crushing strength, and sets of 100 of different kinds of these bricks were fired in industrial furnaces. Five of them were removed after each firing (extending over eight days), and were examined for the determination of deterioration with the different periods of firing. A considerable amount of work was also done on the disintegration of firebricks by sand-blast, and on the action of flue-dust on refractory material. It has been decided to investigate the manufacture of fire-clay retorts by the process of "casting," and to arrange for them to be tested in gasworks under ordinary working conditions.

The report described the electrically heated furnace which has been designed for heating the firebricks under a measurable load. The first measurements were directed toward finding the relation between the temperatures in the interior and the exterior of the test piece. Briquettes of various sizes were made, some with one and some with two holes, so that pyrometers could be inserted into them. Over 100 deg. difference between the interior and exterior was found on a three to four hours' heating and also on a 12 to 13 hours' heating. The need for keeping the interior and exterior at as nearly the same temperature as possible limits the size of the test piece. Test pieces of 4 sq. in. section area were finally used; with these the temperature can be maintained so that the interior is from 20 deg. to 50 deg. less than the exterior on a four hours' heating.

The flux or matrix which binds the constituents of the firebrick together is quite different in the grog from what it is in the clay, even though the grog is made from the very same clay as is subsequently used for making the bricks. This is due to the fact that in the grog the fluxes of the clay have dissolved so much of the less fusible constituents that it is less fusible and more viscous than the flux in the original clay. When the clay and grog are fired together, the flux of the clay softens at a much lower temperature than that of the grog; so that the fluxes of the clay and of the grog do their work independently.

Firebricks with coarse grog are liable to break down mechanically by a diagonal shear, whereas with finer grog the collapse appears as if the actual fusion temperature is reduced, for the test pieces bulge as was the case with the fireclays indicated in a previous report. During the burning of the firebrick the clay does not get so good a grip of coarse grog as with fine grog.

The authors are of the opinion that if a single specification test is to be prescribed for refractoriness under load, 50 lb. per sq. in. is too great. A smaller load would give clays with a higher softening temperature a better chance. The most instructive test would be a curve showing the behavior of the refractory unloaded and with at least two different loads; but if one test is to be presented, a load of 25 lb. or 30 lb. per sq. in. will probably suffice.

In general the silica bricks stand up under load very much better than firebricks made from fireclays; but the finer-grained silica bricks do not stand under load so well as the coarser-grained silica bricks. Indeed, very fine-grained silica bricks show as large a difference between the normal refractoriness and the refractoriness under load as bricks made from fireclays.

Firebricks under load seem to break down in one of two ways. In one type of collapse ("fusion collapse") they gradually give way as the temperature rises, until finally the piece collapses. This behaviour is typical of aluminous and zirconia bricks. In the second type of collapse ("mechanical collapse") the firebrick may show symptoms of a gradual deformation; but the characteristic feature is a more or less abrupt collapse. This is typical of silica and siliceous bricks, and, to a less degree, of magnesite and chromite bricks, although a sufficient number of varieties of the latter have not been determined to give the same confidence in making general statements.

The effects produced are exceedingly complex; and they are affected by many factors other than composition. The texture is one of the most important, but even here there are cross results. As a first approximation, a firebrick can be regarded as a mixture of certain materials which are difficult to fuse with a more fusible constituent. During the firing of the brick the more fusible constituents form a matrix binding the other materials together. The matrix, particularly in the coarser-grained material seems to determine the refractories under load. One red firebrick collapsed under load at a temperature nearly 500 deg. lower than under no load. In this case the matrix suddenly lost its binding power under the load. A firebrick fortified with silica grog may stand up under no load better than the brick without this grog; but with the load the ground mass gives way without being fortified by the grog.

The refractoriness under load appears very much more complex than was at first supposed. The red firebrick referred to does exceedingly good work in the building of the settings of gas retorts—in fact, it has long been a favourite. It collapses mechanically at approximately 1,140 deg. C. under a load of 50 lb. per sq. in. This seems an exceedingly bad result. How comes it that a brick can possess a refractoriness under load which is far lower than the temperature at which it is doing good work in a furnace? By fitting pyrometers into three holes of different depths it was found that in the steady state when the face of the brick is at 1,000 deg. the temperature of the interior is 720 deg. 3½ in. away 570 deg. 4¾ in. away, and 350 deg. 6¼ in. away. Under normal conditions the temperature of the interior would probably be hotter than this; but, in any case, it follows that, although the face of the firebrick may be soft under a load, further inward the temperature is lower; and if the brick is not inclined to spall, the softening of the face would in most cases do good, not harm.—*Engineering Supplement of the London Times.*

Animal Weather Prophets

OUR prairie dogs appear to be quite reliable forecasters of the weather, and this has been particularly noted the past spring, when there were numerous, heavy rains. On a number of occasions the larger members of the colony were observed to be loosening the earth around their mounds with their forefeet, then shovelling the soil upward with the hind feet. Other members worked within the burrow throwing out earth to aid in the building process. When the borders of a crater had been considerably raised the animals went to work tamping down the earth with their heads. This is an amusing process. They look like miniature goats, pounding the ground with the tops of their heads. These operations invariably took place before a rain, and the object was the construction of a circular dyke to prevent water running down the burrow.—*Bulletin of the New York Zoological Society.*

An Optical Method for Accurately Dividing a Circle into Degrees*

By Dr. R. S. Clay

It is very generally known that the image of the pupil of the eye seen through the hypotenuse face of a right angle prism and formed by two reflections in the other faces will be circular if the angle between those faces is correct, but will be shaped as in Fig. 1 if the angle is too small, or as in Fig. 2 if the angle is a little greater than

FIG. 1. FIG. 2.

a right angle. It is not so well known that this is equally true if the angle between the two reflecting faces is 60°, 45°, 36°, 30° and so on, obtained by dividing 360° by the even numbers 6, 8, 10, 12, etc. This really means that if the mirrors accurately make those angles with one another, the final image formed by the successive reflections is in the same place whether the first reflection takes place in one mirror or in the other. For instance, if A and B (Fig. 3) are two mirrors inclined at an angle of 60° and C is an object between them, a series of reflections beginning in the mirror A will give the successive images CA, CAB, CABA. A second series beginning in mirror B will give CB, CBA, CBAB. If the angle is exactly correct CABA and CBAB will coincide. But if the angle between the mirrors be increased by an angle δ, the images will separate by an angular amount equal to 4 δ. Thus it is possible to set a pair of mirrors at these angles to one another to an accuracy limited only by the resolving power of the instrument. (By a wooden model of two discs rotating on a steel spindle, each carrying one mirror, the images of a small circular aperture were projected on to a screen, and their coalescence shown, when the angle between the mirrors was adjusted, to be exactly a right angle.)

To use this principle to divide a circle a rectangular plane parallel glass is front-silvered, and is mounted on the circle to be divided with its silvered surface containing the axis of rotation of the circle and one edge coincident with that axis. We will call this the mirror A. A second similar mirror is mounted on a fixed arm, also with one edge as nearly as possible coincident with the axis of rotation of the circle, and in the first instance with its plane coincident with that of the first. We will call this the mirror B. These adjustments are made by means of an autocollimator carried on an arm which can be rotated about the axis of the circle. The two mirrors will be in one plane when the reflected images in the collimator coincide. The circle, carrying the mirror A with it, is now rotated approximatly through 90° so as to bring the angle between the mirrors to a right angle. The final adjustment is effected by the autocollimator which is rotated through 45° so as to be about equally inclined to the mirrors. When the angle between the latter is correct, the reflected images seen in the collimator coalesce into a single one. In exactly the same way, the positions of the circle for which the angles between the mirrors are 60°, 45°, 36°, and 30°, are found. (At 60° and 36° the collimator has to bisect the angle between the mirrors or the images will not be in the field; at the other angles the collimator can be in any position.)

Each position of the circle found as above must be recorded in some way, depending on the object desired. If it is required merely to divide the circle, there would be a tool to draw the line, as on an ordinary dividing engine. If a master circle is required for the purpose of dividing others, a hole, either conical or cylindrical, may be drilled. Or a wheel with 360 (or some multiple or submultiple of 360) teeth may be made of steel with case-hardened teeth, and one of these teeth may be accurately corrected by a grinding wheel at each determined position.

So far the positions of the divisions 0°, 90°, 120°, 135°, 144°, 150°, have been found. To find other positions the mirror B is moved. For instance, when A has been set at the 90° as above, B is moved through 90° until it is once more in the same plane as A, and then A is moved as before; this will give the positions 180, 210, 225, 234, 240. By repeating this the positions 270, 300, 315, 324, 330 are found. And, in fact, it is easy to see that all divisions down to 3° can be obtained. Or, having once obtained the main divisions by this method, the repetition of the smaller divisions between them may be carried out by one or other of the ordinary methods, *e. g.*, by the use of a pair of microscopes.

For the final subdivision another property of a rotating mirror may be very conveniently made use of. When a ray of light is reflected by a mirror, rotation of the mirror about an axis perpendicular to the plane of incidence will rotate the ray through double the angle that the mirror is turned through. If a ray is reflected to and fro between two mirrors, and one of the mirrors is rotated about an axis perpendicular to the plane of incidence, the emergent ray will be rotated through an angle 2 *n* times the angle through which the mirror is turned if *n* is the number of times the ray is reflected by the moving mirror; for instance, if the ray strikes the rotating mirror three times, it will be turned through an angle six times as great as the angle the mirror is turned through.

To apply this principle, a mirror A (Fig. 4) is mounted as before on the circle. The light from an autocollimator

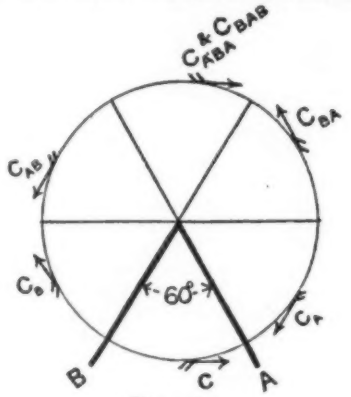


FIG. 3.

C is reflected by A and falls normally on a mirror M by which it is returned in its path to C. M is adjusted until the image coincides with the original scale in the autocollimator. The circle carrying the mirror A is now turned to A^1, through the angle which it is desired to divide, and a second mirror N is adjusted to return the light to the autocollimator. Next, without disturbing M or N_1 the mirror A is moved forward, and an extra mirror B (Fig. 5) carried on a fixed support, is set up parallel to A. The distance from A to B must be half the distance from O, the center of the divided circle, to A. A and B and the collimator are adjusted to return the light after reflection at M to the autocollimator. Then, without moving B or C, A is rotated until the light is returned to the autocollimator after reflection at N. A will have been moved through one-sixth of the angle between the faces of M and N, *i. e.*, one-third of the original angle which it was desired to divide. Thus the divisions can be carried out to single degrees.

The advantage of this method is that it is not a trial and error method, but an absolute one, and that the accuracy of divisions obtained is limited only by the efficient resolving power of the instrument employed.

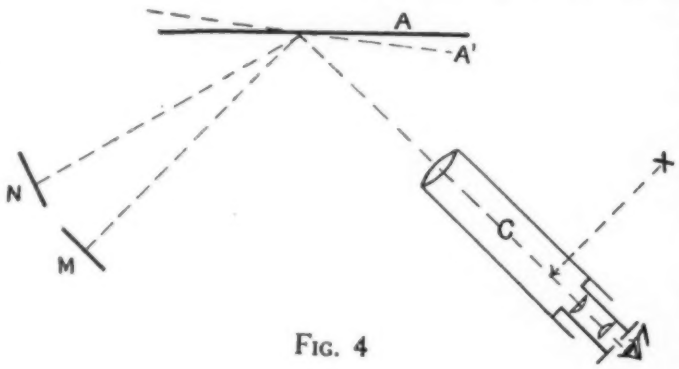


FIG. 4

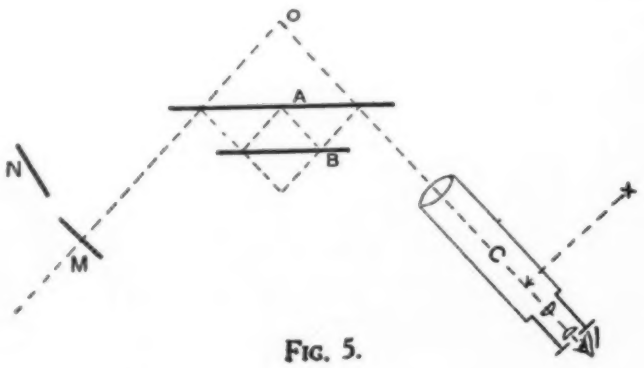


FIG. 5.

DISCUSSION

MR. S. D. CHALMERS said that some time ago he had had occasion to examine optical methods of dividing a circle into degrees, and a method somewhat similar to that indicated by Dr. Clay was among those considered; he had to decide what telescope would be required in order to get the necessary accuracy for a big circle such as was used in dividing engines. The makers were trying to get the original divisions to about 1-10th of a second; they did not get it, but that was what was aimed at. It was not practical to use a telescope of such a resolving power, but he believed it was quite possible actually to attain the degree of accuracy by a comparatively small modification of Dr. Clay's method. To observe the coincidence of the two images with sufficient accuracy, he thought it would be necessary to insert in front of the telescope two apertures, and to observe carefully the actual way in which the diffraction bands appeared on the overlapped images. In that way he believed it would be possible to check the two right angle and other submultiples of two right angles with very considerable accuracy indeed. It would require a magnificent telescope, a very careful observer, and very delicate conditions with regard to temperature and otherwise before it would be possible to approximate the accuracy of the present mechanical method.

Mr. T. Smith thought that although Dr. Clay's method might be useful in cases where only tolerable accuracy was required, it would not work when very great accuracy was needed. There were several conditions necessary to be satisfied in a measurement of this kind before any high accuracy could be attained, and they were conditions which were usually entirely overlooked when new methods of measurement were proposed. In the first place it was assumed that one had a perfect collimator; then it was assumed that the perfect collimator was perfectly focussed. Actually, those conditions were very difficult to realize. It was necessary to remember that if there was any error in focussing, so that the light was not exactly focussed upon the focal plane of the collimator, very important errors would result, which might be many times as great as those present when purely mechanical methods were employed. In general it might be said that if an angle was to be measured with an autocollimator, the beams defining the angle must not lie in the plane of the angle. In measuring the horizontal angles between beams emerging from two mirrors, the mirrors must not be side by side, but one vertically above the other. It had been shown by Guild in a paper read before the Physical Society, that error in focussing, unless this condition was satisfied rendered the apparent accuracy illusory.

When great accuracy was desired, and only part of the objective aperture was utilized by each beam, it was also necessary to make sure that the effects of zonal differences of aberration were eliminated.

The trouble involved in satisfying the conditions necessary to secure high accuracy in this problem was really so considerable that in practice, it would be very much easier to make the adjustments entirely by mechanical means.

AUTHOR'S REPLY

It is, of course, quite true, as Mr. Chalmers suggests, that a very large instrument would be required to obtain an accuracy of one-tenth of a second, and it is to be confessed at once that he had had no thought of attempting to obtain such an accuracy. On the other hand it is equally true that such an accuracy could only be of use, as Mr. Chalmers himself points out, with a telescope which has an objective 30 inches in diameter. Moreover, on a circle 4 ft. in diameter the divisions would have to be able to be read to nearly a ten-thousandth of an inch, which would require a high power microscope. Slight flexure or temperature varia-

*Transactions of the Optical Society (London).

tions of fractions of a degree would vitiate the readings. In other words, it is an impracticable order of accuracy. The best theodolites are divided to ten seconds, and may perhaps be accurate to this order. As a 4-in. telescope is more than sufficient to give this accuracy with this method, it should be good enough for all ordinary purposes.

In reply to the President he would point out that gun sights, compasses and other similar munitions instruments are only required to be accurate to one to five minutes, which is easily within the range of the method.

Mr. Smith's criticisms of the autocollimator are valuable, and it is of course obvious that care must be taken that it is not introducing errors. But these errors ought to be able to be kept within such limits that the method can be used for all ordinary commercial purposes. Whether it can be refined to the last limits will require further investigation. It is to be noted that any error introduced by the collimator is divided by two in the original setting of the mirrors A and B in one plane, and by at least four in the other positions.

It is, however, possible to avoid the use of the autocollimator altogether, and substitute an interference method for the original setting and for the angles 60° and 36°; also for subdividing the angles ultimately. By this variation it may be possible to approach even to the accuracy suggested by Mr. Chalmers.

Dr. Clay adjusted the model for use with an autocollimator kindly lent by Mr. Newman, so that members were able after the meeting to appreciate the sensitiveness of the method.

Prevention of Coal-Dust Explosions in Mines

WIDESPREAD coal-mine explosions start from an ignition of gas or of coal dust or of a mixture of the two. Prevention of such explosions can be accomplished by removing the sources of ignition, or by removing or rendering inert any material that may be ignited. The safest plan is to attempt to do both.

Ignition of gas and dust is possible from open lights, sparks, arcs, or flames from explosives. The use of oil or gasoline permissible safety lamps or miners' permissible electric safety lamps instead of the common oil lamps, the removal of electrical apparatus from places where ignition may be caused, or safeguarding such apparatus so as to prevent its causing ignition, and the use of short-flame permissible explosives to blast down coal that has been properly mined or sheared are precautions that eliminate largely the possibility of an ignition.

Gas ignition can be prevented by providing ventilation adequate to dilute gas at all points where it is generated and adequate to prevent accumulations of gas. In any mine in which open lights are used, it is desirable that the proportion of gas in the returns should not exceed 0.25 per cent. In the returns of any mine in which permissible lights are used, sufficient volume of air should be introduced so the proportion does not exceed 1 per cent. Ventilation should be so controlled that not more than 2 per cent of gas can be detected at any point in the mine.

In attempts to prevent ignition of coal dust, effort is made to prevent as far as possible accumulations of coal dust, and by wetting the dust to render inert coal-dust accumulations that do occur so that the dust can not be blown into a cloud, or by adding incombustible matter enough to render the cloud nonexplosive.

Coal-dust accumulations can largely be avoided by replacing all shooting off the solid by shooting after the coal has been mined or sheared, using tight cars, loading cars so that the coal will not be spilled over the tops, and frequently cleaning the roads.

There are several ways of rendering coal dust inert by wetting. The air current can be humidified with exhaust steam or sprays either after being preheated by passing over and through radiators, or without preheating. If enough steam is added to saturate the air current at the mine temperature there will be no evaporation of water in the mine. However, in winter it is difficult to keep the current saturated and it is usually necessary to supplement humidifying with some watering.

Watering is used in many mines where humidifying the air current is not attempted. A water car or hose from pipe lines may be used. Water cars are of several types. In one type the water merely dribbles on the middle of the road; in another the water is under pressure and a strong spray is thrown on all surfaces of the entry as the car passes. The use of hose to wash down all surfaces thoroughly is the best method if done frequently enough. In winter it may be necessary to sprinkle throughout the mine every day.

Deliquescent salts, usually common rock salt and calcium chloride, are also used for wetting dust. The former is slightly deliquescent, and does no good except when the air is nearly saturated; then the salt becomes moist and helps to wet the dust. Calcium chloride is more efficient; applied in quantities of about 2 pounds per foot it will keep a roadway moistened for two or three months, depending on how fast the coal dust accumulates. However, this method does not care for dust on ribs, roof, and timbers.

The dry method of rendering coal dust inert, termed rock dusting, has been used only during the past eight years. Applying dry incombustible dust to the ribs, roof, and floor of entries, air courses, and rooms, after they have been cleaned as thoroughly as possible of coal dust, affords efficient protection for a long period, until enough coal dust accumulates to make the mixture of rock dust and coal dust explosive.

Atkinson in 1880 and Garforth in 1886 noted in England, and Rice in 1892 in the United States, that after certain mine explosions the tram roads on which there was much incombustible matter showed hardly any explosion effects. It was noted in Germany that fine sand spread over coal dust appeared to prevent the spread of flame from a blow-out shot. Although these facts were recorded at the time, the idea of using incombustible dust to prevent coal-dust explosions developed slowly. For this development Mr. Garforth was largely instrumental. In 1908, in the experimental gallery of the British Government at Altofts, England, a stone-dust zone 300 feet long extinguished the flame from a 170-foot zone containing much coal dust. Seemingly this was the first occasion on which rock dust was used to check explosions.

At about the same time in France Mr. Taffanel began experimenting along the same lines. In 1911 the United States Bureau of Mines began similar testing on a large scale and for the first time this was done in a real mine.

In 1912 a British commission that was in charge of the Altofts experiments issued a preliminary report recommending the use of rock dust. In their report they mentioned five British collieries that were then trying rock dust; since then through official approval of the method many mines have adopted the application of rock dust as a safety measure.

In the United States rock-dusting on a large scale was first tried in a Colorado mine, where sprinkling had caused roof falls. The application of dry adobe dust began in March, 1911, and has been continued to date. The first dusting was by hand, as a blower does not give a satisfactory coating when the dust is first applied; for subsequent treatment a rock-dust blower was used. About 10 miles of entry has been kept dusted for about four years, at a cost of about 0.3 cent per ton of coal produced. The dust is obtained from the country roads in a near-by canyon. It costs $1 per ton, and about 2,500 tons have been used. It all passes through a one-eighth-inch screen and probably 20 to 30 per cent. will pass through a 200-mesh screen.

The introduction of rock dusting at other American mines has been slow. In the meantime by actual tests at its experimental mine the Bureau of Mines has been determining the proportion of incombustible that when mixed with coal dust from the Pittsburgh bed, will make a nonexplosive mixture. The bureau has determined that an explosion once started will not propagate through a mixture containing 64 per cent. of incombustible material if not more than 20 per cent. of the dust will pass through a 200-mesh sieve, and if gas is absent from the air current.

There are two general methods of rendering coal dust nonexplosive—first, by wetting the dust to prevent a cloud of dust from being formed because only when the coal dust is in a cloud is it explosive; second by adding to the coal dust enough incombustible dust to make the mixture nonexplosive. The first method is extensively used; the second is comparatively new in the United States. The advantages of using wet dust to prevent coal dust explosions have been pointed out in a preceding chapter.

The first coating is applied by hand and the use of limestone dust gives an entry the appearance of being whitewashed. Later when it is necessary to redust, the dust is blown into the air current by means of a blowing machine and this dust settles down on ledges and surfaces on top of the coal dust that has accumulated, and keeps the latter from becoming explosive.

Ordinarily only the coal dust in the haulage entries is treated, but the parallel air course may contain considerable coal dust that would propagate an explosion. To obviate this danger, rock dust should also be blown into the air course.

The information gained from explosibility tests of the quantity of shale dust necessary to prevent mine explosions is very valuable in developing the rock-dusting method of rendering coal dust inert; if the explosibility of the road dust be questioned, analysis of samples will show whether the percentage of incombustible in the road dust is sufficient to prevent the propagation of an explosion along that road. Rough determination of the percentage of incombustible dust present can be made quickly with an instrument called a "volumeter," designed by Mr. Taffanel, of France.

As has been indicated, in order to have efficient protection from widespread explosions, rock dusting should be done throughout a mine, as no one can forsee at just what point an explosion may start. As long as rock dusting or watering is satisfactorily maintained there should be no danger of an explosion being propagated throughout a mine; but if the method is used and is not adequately maintained there should be supplementary means of preventing an explosion from spreading throughout the mine and possibly causing the death of everyone in it. So-called "rock-dust barriers," based on devices tested in France, have been designed by George S. Rice, chief mining engineer of the Bureau of Mines, and tested at the experimental mine. Models of each of several types were developed which in a large number of tests effectively stopped the propagation of explosions.

One of the most easily constructed and effective of these barriers is known as the "trough barrier." It consists of six or more troughs extending across the entry at intervals of about 6 feet, with the bottom boards held in position by a lever system connected by wires to suspended vanes 100 feet on either side of the troughs. Should an explosion occur the vanes are caused to swing, thus releasing the bottom boards of the troughs so that the dust contents fall to the ground in a dense cloud. This dense dust cloud cools the gases to such a degree as to prevent propagation of flame beyond. The various types of barriers are described in Technical Paper 84[1] of the Bureau of Mines.

Such barriers are feasible at the entrances to all splits of the air current or sections of a mine, and at points along the main haulage roads, so that if an explosion occurs it will be arrested by the barriers, and will not spread throughout the mine. If an explosion should occur in a particular split in which the dust on the roads was explosive, it would not travel beyond the barrier at the entrance to the split. The men in the split might lose their lives, but the men in other parts of the mine would have a much better chance of getting out safely.

Most of the tests made have been in entries or narrow places, because most explosions are initiated in such places. However, as some explosions start in wide places, a few tests have been made with reference to the development of explosions in those places. These test indicate that such explosions can be initiated with comparative ease by a single blow-out shot if enough fine coal dust be present. It was also indicated that cut-throughs (break-throughs) near the point of origin hindered the development of the explosion, as they permitted considerable release of pressure at the time when the explosion is just getting under way.—*Yearbook of the U. S. Bureau of Mines.*

Effect of Silver on Bacteria

P. SAXL, in the *Gesundheitsingenieur* describes his investigations on the effect of silver in destroying bacteria in water. It has for a long time been recognized that water that has passed through copper tubes has certain antiseptic properties, and also that metallic silver immersed in the water has an antiseptic action. On this action the author has based the operation of a drinking-water sterilizing station. By filling a glass bottle to the brim with water, immersing a silver wire in the bottle so as to reach right down the neck, allowing the bottle to stand for 14 days, and then pouring out the water, the bottle is found to be left in such a condition that if fresh water is poured in and a silver wire again inserted, the water is rendered germ-free for eight hours. Tests showed that typhoid, cholera, and dysentery bacteria could be destroyed in this way.—*Nature.*

Influence of Air Pressure on Fermentation

BEER wort was fermented completely in flasks, some of which were closed by means of a sulphuric acid trap and others only with a plug of cotton wool. It was found that in the former case the wort attenuated more completely than in the latter case, though the evolution of gas was more rapid in the flasks closed with cotton wool. The more complete attenuation is attributed to exclusion of air, in consequence of which the yeast is compelled to obtain oxygen by increased decomposition of sugar. The author noted also fluctuations in the amount of gas evolved from day to day, as observed by Rippel, especially in the flasks closed only with cotton wool.—Note in *J. Soc. Chem. Ind.* on an article by H. ZIKES in *Bierbrau u. Maltzfabr.*

[1] Rice, G. S., and Jones, L. M., Methods of preventing and limiting explosions in coal mines: Tech. Paper 84, Bureau of Mines, 1915, 45 pp., 14 pls., 3 figs.

The Waste Sulphate Liquor Problem*

By Bjarne Johnsen

THE pulp obtained by heating wood at high temperature and pressure with a solution of calcium and magnesium bisulphites represents only about 50 per cent of the dry weight of the wood, while the other 50 per cent of the wood substance is contained in the waste liquor, which is not at present utilized in Canada. The utilization of this waste has always been one of the great problems of the sulphite pulp industry, especially in countries which do not possess large forests, as well as in countries where legislation has prohibited the discharge of waste sulphite liquor into rivers which are too small to afford the dilution of the liquor, which is considered necessary to prevent injury to fish life.

It is not necessary to mention all the processes which have been proposed for the utilization of waste sulphite liquor during the last 40 or 50 years; it will suffice to say that they involve uses of a most varied nature, such as the manufacture of tanning materials, cattle food, dyestuffs, preservative for eggs, ethyl alcohol, etc. The object of this paper is to report on certain modern processes, which in some places have gained industrial importance and which might be introduced with advantage into Canada.

According to Klason the chief constituents of European spruce wood average as follows: Cellulose 50 per cent, lignin 30 per cent, carbohydrates 16 per cent, protein 0.7 per cent, resins and fats 3.3 per cent. As most of the analytical work on waste sulphite liquor has been carried out in Europe the figures given below are based upon the composition of the liquor obtained from the cooking of this material. In Canada various species of spruce, fir, and hemlock are used in the manufacture of sulphite pulp. These woods vary considerably in their chemical composition, the cellulose content of white spruce, for example, being about 4 or 5 per cent higher than that of balsam fir or hemlock and the lignin content also varying within 4 to 5 per cent in the different species. The same is true of the carbohydrates and of tannin, the amount of the latter being very low in the spruces and in balsam fir. The composition of the wood also varies in the same tree with the dimensions and the conditions of growth. As to the nature of the substances mentioned above our knowledge is still very limited. Klason considers the lignins to consist of condensation products of coniferyl alcohols and therefore to contain an aromatic nucleus. He also assumes the presence of three ethylene groups and an active carbonyl group which are able to combine with the sulphurous acid of the cooking liquor. On the basis of these assumptions we may consider the main reaction between the lignin complex and the cooking liqour as consisting of an addition of SO^2 to the lignin complex forming sulphonic acids, the barium salt of which has been isolated from the waste liquor by Klason, who established for this compound the empirical formula $C_{40}H_{44}O_{17}S_2Ba$, with a molecular weight of at least 6,000, which indicates the formula for lignin to be $(C_{40}H_{42}O_{11})_6$. The lignin compound is further characterized by a number of reactions showing for instance the presence of methoxyl and acetyl groups. A further action of the liquor in the cooking process is the hydrolysis of the polysaccharaides of pentoses and hexoses which are thereby converted into soluble sugars. The cooking process must be regarded as consisting of a great number of both complicated and simple reactions, which with our present limited knowledge of the constitution of wood we are unable to follow in detail. This fact, as well as the variation in the wood and in the method of cooking, makes it impossible to form any definite opinion with regard to the quantitative composition of the waste liquor, but the composition of the wood substance on the one hand and the purity of the wood pulp obtained on the other hand, as far as we possess methods for determining these factors, give us an idea of the substances which may be expected in the waste liquor.

Waste sulphite liqour has a specific gravity of about 1.05, gives an acid reaction, has a strong reducing power, and contains about 12 per cent of organic and 1 to 1.5 per cent of inorganic substances. The latter originate mainly from the cooking acid but partly from the inorganic substances of the wood, which represent about 0.25 to 0.5 per cent of the dry weight of the wood. Sulphurous acid is present to some extent in the free state and partly so loosely combined with organic substances that it may be removed by heating. Most of the sulphurous acid is, however, present in the form of sulphonic acids. The liquor also contains small quantities of sulphuric, acetic, formic, and oxalic acids as well as traces of citric acid, small quantities of vanillin, furfural, and succinic and protocatechuic acids. A precipitate obtained by addition of animal glue has been used as a reaction for tannin compounds, but the presence of such compounds, at least in any appreciable quantity, is questioned by the tanning industry.

The following summary of the constituents of the waste liquor has been calculated by Klason on the basis of a short ton of pulp:

	Liquor I.	Liquor II.
	lb.	lb.
Lignin	1287	1200
Carbohydrates	622	650
Proteins	31	30
Resins and fats	146	60
Sulphurous acid combined with lignin	470	400
Lime	204	180
	2760	2520

The theoretical yield of by-products is often calculated upon a recovery of up to 1,800 gallons of liquor per ton of pulp, which represents very nearly the total liquor in the digester. As a matter of fact, only about 740 gallons will drain off from the blow pits per ton of pulp, while probably a maximum of 800 gallons could be obtained if the draining were continued for a longer period without the use of any special equipment.

The liquor might now be utilized in one of different ways, either by recovering the total solids as a whole or by isolating one or more of the most valuable constituents. The former method, involving more or less complete evaporation, has been employed at places where a discharge of the waste liquor into the rivers is prohibited. The concentrated liquor is a tar-like product with binding properties, and has therefore been proposed as a binder for powdered materials and for roads. As a result of extensive experiments the U. S. Department of Agriculture classifies concentrated sulphite liquor of specific gravity 1.13 as a temporary or semi-permanent road binder and dust preventive. One half gallon per square yard was found to be effective for a period of six weeks. The cost, including labor and material was estimated at $0.0355 per square yard. Favorable results have also been secured at Queen's University using concentrated liquor as a road-binder. The binding and water-resisting qualities may be improved by emulsifying the liquor with a mineral oil.

It is often desired to remove the lime from the liquor, and this can be effected by the addition of sulphuric acid or a soluble sulphate with subsequent filtration. This is no doubt especially desirable when the concentrated liquor is to be used as a binder for powdered fuel, blast furnace dust, fine pyrites, or foundry core sand. In all these ways the waste sulphite liquor has been used successfully. The hygroscopicity and solubility in water of the binder from waste liquor have been pointed out as drawbacks in its use as a binder for fuel. Several methods have been proposed for the elimination of this disadvantage, such as carbonization of the binding material at a high temperature or the addition of chromium salts and finally aluminium sulphate. The briquettes may also be immersed in a mixture obtained by heating crude petroleum oil with bitumen or phenols to the boiling point, with strong aeration, until a mixture is obtained which solidfies on cooling.

The product known as "zellpech" or "cell pitch" is waste liquor neutralized and filtered through coke and afterwards concentrated to 35° B. or to a solid substance of 10 per cent moisture content. One ton of coal is required to produce a ton of "cell pitch," the heat value of which is 5,700 B.t.u.

An adhesive can also be obtained if the waste liquor is concentrated after the addition of zinc carbonate or oxide, or if the liquor is concentrated *in vacuo* with an excess of magnesium oxide with magnesium chloride added in a proportion equivalent to the excess of magnesium oxide, in order to form the oxychloride. Usually, however, the adhesives are obtained by precipitation with glue or albuminous substances.

A tanning material can be obtained by concentrating the liquor to about 30° B., but it is necessary to remove certain impurities which are detrimental to leather, such as lime, iron, and the free and loosely combined sulphurous acid. The sulphurous acid can be removed by evaporation, with or without the addition of sulphuric acid, or may be precipitated as calcium sulphite by the addition of the required quantity of lime. The organically combined lime is usually removed by precipitation with sulphuric acid or a soluble sulphate. Oxalic acid is often recommended for the removal of the last trace of lime, or lactic acid is used since the resulting calcium lactate has no injurious effect upon the leather. There are a great number of more complicated methods for obtaining a tanning material from waste sulphite liquor, such as the addition of the sesquioxide of aluminium or chromium, the precipitation of an organic cayn-ogen compound from the liquor after a previous heating with potassium or sodium cyanide, etc.

The tanning value of these extracts, known on the market as "sulphite extract," "spruce extract," "Norego," etc., has been the subject of lively discussion. It has been claimed by tanners that these extracts have no tanning value because they do not contain tannin, or at least only very small quantities. This is true, and the reactions obtained from sulphite liquor with glue and with iron solutions, which have been assumed to be reactions of tannin, must be due to the sulphonic acids of the lignin. However, experiments have shown that hide absorbs as much as 23—25 per cent of substances from a "sulphite extract," being transformed into leather which has in some cases surpassed both hemlock and oak leathers in quality. It is not recommended to use these "sulphite extracts" alone, as the best results are obtained in admixture with other extracts, for example quebracho extract, since the "sulphite extract" is a good solvent for the difficultly soluble portions of the quebracho extract, namely, the phlobaphenes. It is also possible by employing "sulphite extract" in mixture with other extracts to obtain a proper proportion between the tannin and non-tannin substances, and to accelerate the tanning process. The low cost of "sulphite extract" (¾—1 cent per pound) results in a considerable saving. The opposition of the tanning industry to this extract may be due to the poor quality of the first products put on the market, but it is generally admitted by the tanners that for certain leathers "sulphite extract" may be used with great advantage and, as a matter of fact, tanning extracts from waste liquor are at the present time imported to Canada and used quite extensively in Canadian tanneries.

It was mentioned above that the "cell pitch" obtained by evaporation of the waste liquor had a heat value of 5,700 B.t.u. but even with modern evaporators a recovery of this product for use as a fuel would hardly be economical. Strehlenert's process for manufacturing fuel from waste liquor is based upon the precipitation of the lignin compounds at high temperature and pressure. The decomposition is effected by the sulphuric acid which is formed from the sulphurous acid present in the liquor. According to the first patents the formation of sulphuric acid is effected by oxidation at a comparatively low temperature by the introduction of air or oxygen into the autoclave. The reaction $4CaSO_3 = 3CaSO_4 + CaS$ takes place subsequently. As copper autoclaves are used copper oxide and finally copper sulphate are formed and the following reactions take place:

$$CuSO_4 + CaS = CaSO_4 + CuS;$$
$$CuS + 2H_2SO_4 = CuSO_4 + SO_2 + S + 2H_2O.$$

The copper therefore causes the direct formation of fresh quantities of sulphur dioxide. It is found, however, that the presence of even small quantities of iron, zinc, manganese, or other hydrogen-forming metals decreases the yield of precipitate considerably. By introducing the air at a higher temperature the oxidation and decomposition take place simultaneously and so rapidly that the action of the metal is eliminated. The formation of SO_3 at lower temperatures is avoided by introduction of SO_2 from the sulphite digesters. When the sulphuric acid is formed at high temperatures the reaction may be expressed by the equation: $3SO_2 = 2SO_3 + S$, and theoretically no air is required. But the presence of air is of advantage, as it causes the organic compound to be precipitated in a coarser form. The new autoclaves are lined with lead to prevent the reaction between the SO_2 and the autoclave material. The reactions may then be expressed as follows:

$$4CaSO_3 = 3CaSO_4 + CaS;$$
$$CaS + H_2SO_4 = CaSO_4 + H_2S.$$

In this process only 75 per cent of the total solids is precipitated, and Strehlenert concludes that this portion consists of compounds of sulphinic acids, the remaining 25 per cent consisting of sulphonic acid compounds. In his calculations Strehlenert assumes a liquor recovery per ton of pulp of 1,200 gallons, or 1,800 gallons when diffusers are used. He also assumes the most favorable conditions with regard to yield and to the concentration of the liquor (namely, 17 per cent solids). The operating cost per short ton of fuel in a Scandinavian plant is $2.88, according to Strehlenert's calculations, including depreciation, labor, and repairs, assuming a recovery of 1,200 gallons of waste liquor per ton of pulp in a plant having a capacity of about 20,000 tons of pulp per year. But this fuel is of an inferior quality, containing about 18% ash and about 50% of water. Considering these two points the cost would be equivalent to $4.75 per short ton of good coal of 14.400 B. t. u.

Assuming the concentration of the waste liquor to be 11 per cent, however, and considering the higher cost of labor, etc., in North America, the manufacturing cost of recovered fuel will be equivalent to $6.80 per ton of good coal of 14,400 B.t.u. on the basis of a 33,000-ton pulp mill and a recovery of 800 gallons of liquor (328 lb. of fuel) per ton of pulp. On the basis of 1,200 gallons of liquor (492 lb. of fuel) per ton of pulp, the manufacturing

*A paper read before the Canadian Section of the Society of Chemical Industry. From a report in the Journal of the Society.

cost of recovered fuel would be equivalent to $6.35 per short ton of coal of 14,000 B.t.u.

This cost could probably be somewhat reduced by the recovery of by-products such as acetone, acetic acid, formic acid, and methyl alcohol, but in the present form this process would hardly be of practical interest to the Canadian industry. Under the conditions, however, which at present prevail in Scandinavia the process is of considerable value. At least one plant is in operation in Norway, and orders have been placed for several plants of the same type in Sweden, Finland, and Russia.

When certain by-products are recovered by destructive distillation the fuel process appears to better advantage. It has been found that distillation of the precipitate gives 56 per cent of charcoal, 18.7 per cent of crude acid, 2.1 per cent of tar, and 23.2 per cent of non-condensable gases and that there are present in the crude acid, on an ash- and water-free basis, 1.0—1.1 per cent of methyl alcohol, 0.12 per cent of acetone, 0.45 per cent of acetic acid and 0.014 per cent of formic acid. The economy of destructive distillation of the residue has not yet been sufficiently investigated.

A process which has been more seriously considered in America is the manufacture of ethyl alcohol from waste sulphite liquor. The amount of fermentable sugars in the liquor varies considerably since their formation from the lower hexosans of the wood as well as their destruction in the cooking process depends largely upon the strength of the acid and the temperature during the last part of the process. Usually the liquor contains between 1.5 and 2 per cent of fermentable sugars, but in some cases this value may be as high as 2.4 per cent. Klason found a waste sulphite liquor to contain mannose 0.526 per cent, galactose 0.274 per cent, dextrose 1.65 per cent. Of these sugars galactose ferments more slowly than the others, and the highest yields of alcohol obtained namely, 1.4 per cent by volume of the liquor, corresponds approximately to the mannose and dextrose content. On an average only 1 per cent of alcohol is obtained on a commercial scale, although Landmark claims an average of 1.1 per cent for his process, and the Marchand process is said to give 1.25 per cent of alcohol.

The principle of the various processes of manufacturing alcohol from waste liquor is the same. The free sulphurous acid, which is strongly toxic to yeast, is partly removed by evaporation and partly by neutralization to a point of acidity favorable for fermentation. The difference in the various processes lies mainly in the method of neutralization. It is not advisable to neutralise with lime alone, as a large excess is required, causing the destruction of a large proportion of sugars and an undesirable turbidity of the liquor. In the Swedish plants which are operating under Ekström's and Wallin's patents, a smaller quantity of lime with the final addition of calcium carbonate effects the neutralization. In Marchand's process barium carbonate is used, while in Landmark's only calcium carbonate is employed. The waste liquor does not contain nitrogen and phosphates in the quantity required for normal fermentation and if yeast extracts which do not contain the necessary amount of these substances are used they must be added to the liquor in a suitable form. In Ekström's process a "tempered yeast" is added which is prepared to meet the special condition of the sulphite liquor. This is not necessary in Landmark's process; in this case milk or whey is heated with acid, the precipitate of "lignocasein" (which can be used in paper sizing) is filtered off, and the filtrate added to the liquor, which can then be fermented directly with ordinary brewers' yeast. The cost of the milk is said to be covered by the value of the "linogcasein."

Hagglund has calculated the cost of manufacturing 100 per cent alcohol based upon a recovery of 800 gallons of liquor per ton of pulp. His calculations are based on 30,000, 20,000, and 10,000 ton mills in Scandinavia. However, if we assume for Canadian conditions that the costs of plant, labor, salaries, and repairs are 50 per cent higher than in Scandinavia, and if we further allow 15 per cent depreciation and interest, the total cost of one Imp. gallon of 100 per cent alcohol will be $0.220, $0.251, and $0.321 on the basis of a 30,000, 20,000, and 10,000-ton pulp mill respectively.

The manufacturing cost estimated by Landmark for his process is not directly comparable with the figures given above because he bases his calculations on a recovery of 1,400 gallons of liquor per ton of pulp and upon a plant connected with a 15,000-ton mill. It is, however, possible to bring these calculations to a certain accordance with those used in the discussion of the previous process whereby the cost of production, including depreciation and interest and cost of handling, would be very close to $0.19 per Imp. gallon of 100 per cent alcohol, which is appreciably higher than the cost estimated by Landmark himself. With regard to the cost of production of alcohol, reference may be made to an article by Breckler (see J. Ind. Eng. Chem., 1917, 9, 612; this J., 1917, 902) giving the average cost of alcohol from grain for the past five years as high as 17.5 cents per proof U. S. gallons or about 24 cents per Imp. gallon, corresponding to $0.48 per Imp. gallon of 100 per cent alcohol, which is considerably higher than the cost of sulphite spirit. The crude sulphite spirit contains about 3 per cent of methyl alcohol. The two alcohols can be separated, but this is not necessary as the spirit can be used in the crude form for industrial purposes, as motor fuel, for illumination and cooking, replacing gasoline and petroleum. In its eighth annual report, the Commission of Conservation points out the importance of establishing an alcohol industry as Canada is now dependent upon foreign sources for her supply of petroleum and petroleum products.

The production of sulphite spirit has already reached commercial importance in other countries. In Norway two plants are in operation, while four plants in Sweden are producing one million gallons per year and three more plants are being erected. In Germany 13 plants are being built or are probably now in operation and in the United States two, and in Switzerland one plant is operated. Considered from the standpoint of utilization of waste liquor this process does not solve the problem completely, as the fermentable sugars represent only 15—20 per cent of the total solids, but the remaining liquor may be used in one of the other processes, for instance, for the recovery of a binding material, or fuel, or for destructive distillation of the dry residue obtained by evaporation.

Waste sulphite liquor has also been suggested for use as a fertilizer, but in this case its value is only indirect as it contains the substances required for a good fertilize in very small amounts. In mixture with other substances it may be of some value for poor soils because of its content of organic substances which form a good medium for the growth of nitrogen-forming bacteria.

As the amount of solid substance in the waste liquor is very low (only 11—12 per cent), the economy of most of the processes suggested for its utilization depends largely upon the cost of concentration. A much higher efficiency is claimed for a new type of evaporator which is now built in Sweden and by which the heat of the vapors from the liquor is utilized much better than in the usual multiple effect evaporators. Oman has recently announced a quite different method of concentration, namely, by freezing. The liquor can be concentrated to one-fourth of its original volume much cheaper than by evaporation. No details regarding this new process are yet available, and it would probably only be feasible in countries with cheap water power and high coal prices.

The Canadian sulphite pulp industry consumed in 1916 about 728,000 cords of wood. This means that approximately 1,000 tons of wood substance was carried away daily as waste with the liquor, and it shows that it would mean a tremendous saving for Canada if existing processes could be adopted or new methods developed by which this waste could be eliminated or at least considerably reduced in an economical way.

In conclusion, I have to thank Mr. O. F. Bryant, of the Forest Products Laboratories, for the valuable assistance given me in the preparation of this paper.

Low-Grade Fuels*

Possible Methods of Disposal

THE question of the disposal of low-grade fuels is one which concerns not only gasworks and coke-oven establishments, but also those collieries in which it is customary to submit the coal before dispatch, to the process of washing. On most gasworks there is to be found a residual in the shape of coke-dust, *i. e.*, the material passing through a ⅜ in. mesh, which cannot be satisfactorily employed in the ordinary coke and breeze furnace. The result is that in many instances the material has to be relegated to the rubbish heap. Other forms of low-grade fuel which, though of too valuable a character to be regarded as waste, have proved particularly difficult to turn to useful account in practice are small coal, belt pickings, and washery dust, while the question assumes very much greater importance when consideration is given to the practice of leaving low-grade coals below ground.

The subject of the poorer fuels has recently been dealt with in an illuminating manner by two experts who can speak of the subject from a practical as well as a theoretical standpoint. Professor J. W. Cobb lectured at Leeds University to a meeting of coke-oven engineers, while Mr. W. Chaney, the engineer of one of the large Birmingham gasworks, related his experience with coke-dust before the Midland Association of Gas Engineers. The most obvious method of utilizing a particularly small fuel is to burn it, with the aid of a forced or impelled draught, in a furnace such as is commonly employed for use with a coke and breeze mixture. The difficulty, however, as Professor Cobb shows, is that a bed of extremely fine fuel acts like a sand lute, which is best known in its use as a particularly effective gas seal. Consequently it is impossible, with reasonable pressures, to force any considerable quantity of air through the mass, although it is of quite a porous nature; moreover, if the air pressure is increased beyond a certain limit, the body of material "blows," with the result that the air current is entirely localized, especially with a non-caking fuel such as coke-dust.

*The London Times Engineering Supplement.

FUEL SPRAY BURNERS

A special form of apparatus which has been introduced with the object of obtaining a perfectly free air supply for every particle of fuel is that which entirely dispenses with the fuel-bed and utilizes in its stead a continuous stream of fuel dust carried forward in suspension by the air supplied for its combustion. In the Bettington spray boiler the fuel dust is propelled in a horizontal stream by a blast of air, the blast carrying the coal from a separator and thence through a fine sieve to the base of a vertical water-tube boiler. The spray of fuel-laden air then burns as a huge jet, through a water-cooled nozzle placed vertically in a firebrick combustion chamber. The hot products of combustion on reaching the top of the chamber take a downward course over a fireclay lining adjacent to the inner side of the vertical water-tubes, and on reaching the bottom of this duct they turn upward along the outer side of the tubes, thence finding their exit to the chimney by way of a special tubular heat exchanger. This heat exchanger is of the nature of a regenerator, the hot products imparting a portion of their heat to the inflowing air-blast. In the ordinary way, if a fuel-dust is propelled in a horizontal stream there is a tendency for the heavier particles to drop out and escape combustion, but with the upward vertical spray these particles can only drop back into the zone of combustion.

Professor Cobb is of the opinion that a system of this nature is primarily suited for use with coal dust, for analyses of the "flyers" escaping from the chimney indicate some incompleteness of combustion. If this happens with the dust from coal, there is every probability that more serious loss would take place with a fine coke breeze, which is very much more difficult to ignite and oxidizes more slowly. There is, moreover, the difficulty, from a mechanical point of view, of dealing in practice with an intrinsically hard material which is less amenable to sieving and suspension. It seems that this type of boiler is likely to raise another problem for the manufacturers of refractory materials, for the working temperature being extreme a large proportion of the ash fuses on the inner surface of the combustion chamber, and, running down as a slag, is removed at the bottom. As is well known to the user of refractories, this slagging action is particularly liable to be followed by incipient fluxing of the fire-work, an effect which would be considerably magnified in the event of a coke-fuel containing very much more ash being employed.

USE IN PRODUCTS

At Birmingham Mr. W. Chaney is in a unique position for a gasworks in that he has a large system of carbonization plant fired entirely by means of producer gas of the Mond description. Originally the producers were designed for the utilization of coal slack, but as a good deal of coke-dust, which had to be carted away as rubbish, was available experiments were conducted to determine whether or not it could be used as a substitute for the coal slack. The calorific value of the dust is about 10,000 B. t. u. per lb. on the dry basis, and it has a nitrogen content of about 1 per cent, the sulphate of ammonia recoverable being equivalent to from 45 lb. to 50 lb. per ton of the dust, or double the quantity obtained from a similar weight of coal when carbonized in the usual manner. From the point of view of nitrogen recovery the disposal of coke-dust in this manner presents an attractive prospect, for Mr. Chaney estimates that from 3 to 4 per cent of the total coal carbonized for gas-making purposes is representative of the quantity of coke-dust made, so that the system offers a new and considerable source wherewith the nitrogen supplies of the country might be augmented. In fact, if all the coke-dust produced could be treated for recovery in some such manner the available supplies of sulphate of ammonia would be augmented by 30,000 tons per annum.

When gasified alone in the Mond producer the dust yields about 95,000 cu. ft. of gas per ton, the calorific power of the gas being 114 B.t.u. per cu. ft. As might be expected, however, the capacity of the producers—designed for coal slack—is somewhat seriously affected by the use of coke-dust; it was found impossible to maintain the working heats in the retort setting, and the tests had to be discontinued. Under such conditions the most satisfactory way out of the difficulty was

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found to be that of utilizing a mixture of coal slack and coke-dust, the most suitable proportion being 60 per cent of the former and 40 per cent of the latter. In this way the calorific value of the resultant gas was increased to 130 B.t.u. per cu. ft., the average price of the mixed fuel working out at about 11s. a ton, as against 17s. 6d. for coal slack alone. But when consideration is given to the additional revenue from the sulphate recovered, the net cost of fuel is reduced to the extremely small figure of 1s. 1d. per ton. It would seem that the mixed fuel method is perfectly practicable, and no untoward results have followed its adoption. For every ton of the fuel gasified 2½ tons of steam are supplied. One ton of this steam is recovered by the cooling of the producer gas, while the remainder can usually be obtained by collecting together the many streams of exhaust steam invariably to be found on a works of any magnitude.

THE MARCONNET PRODUCER

An uncommon form of producer for disposing of low-grade dust fuels, and one of which Professor Cobb speaks in more or less favorable terms, is that known as the Marconnet. In this system it is claimed that fuels ranging from those devoid of volatile matter, such as coke-dust, to coals containing from 30 to 35 per cent can be used, that 5 to 30 per cent. of ash offers no difficulty, and that even a shale containing 70 per cent of ash can be employed satisfactorily. Professor Cobb thinks, however, that some trouble might be occasioned owing to the gas produced being of an insufficiently regular quality for successful use in gas engines. In the Marconnet producer the dust is fed, in the form of a fine rain, into an air-blast fan, which propels the air thus charged with particles of fuel into the gas producer. The fuel-blast enters the producer tangentially thus giving a swirling motion, and the producer gas leaving the top is passed through a filtering layer to free it from any suspended particles.

COKE DUST IN THE MOND PLANT

Speaking of the disposal of coke dust in the Mond producer, Professor Cobb says that difficulties are sure to be encountered in practice, because this fuel, being of a non-caking character, interposes some considerable resistance, and thus there is a tendency toward blowing into channels. Moreover, any sudden passage of air, if in any quantity, through one of these channels introduces in a producer a special danger which is absent in the case of the ordinary boiler, insomuch as the free oxygen would burn the gas above the top of the fuel-bed and might be present in quantities sufficient to cause explosion. Furthermore, since the fuel-bed has no power of cohesion, it has the liquid tendency to seek its own level and to run rapidly and suddenly out of the bottom lute. This action, which is followed by a lowering of pressure in the upper portion of the producer, might give rise to the in-drawing of air through imperfect joints with consequent danger. Again, the settling of the fuel-bed in a producer is determined by the combustion of the fuel and the removal of ash from the bottom of the producer, and this process, if the fuel is devoid of cohesion, is not in itself likely to lead to a uniform subsidence over the whole cross-section of the producer, but to curious tunnelling and other irregularities. This phenomenon, Professor Cobb points out, has been studied in connection with blast furnaces and large hoppers used for grain storage. It may also be observed in coal bunkers, and is of importance in gas producers, particularly when a non-caking fuel is used. If the fuel is of a caking character the inconvenience of impenetrability on the other hand is brought to an extreme by the semi-fusion of the coal. It may be gathered, therefore, that a definite mixture of caking and non-caking fuel, as utilized by Mr. Chaney, provides a means of surmounting the problems associated with the physical condition of the fuel-bed.

ALTERNATING METHODS

Professor Cobb is not altogether sanguine as regards the general adoption of granular fuels for gas production. He considers, in fact, that the difficulties encountered may be so considerable that a solution will have to be sought in the effective breaking up of the structure of the fuel-bed so as to permit of conditions approximating more closely to those obtaining with the ordinary fuels. One method of doing this is to mix a suitable proportion of coke or coal with the dust, the practice adopted by Mr. Chaney. Another method is that of subjecting a portion of the fine fuel to a simple and effective briquetting process. The way would then be open to the treatment of fine fuels by standard methods of carbonization or gasification, and to obtaining a yield of by-products, without, of course, counting too much on the value of the coke produced, but rather looking to a combination of the carbonizing process with an after-treatment in producers, under conditions favorable to an optimum yield of gas and residuals.

Soy-Bean Cheese

SOME preliminary experiments have been made to determine the conditions of making and ripening the Chinese soy cheeses.

The presence of a protein allied to the casein of mammalian milk makes possible the manufacture of these cheeses. The basis of these is the so-called Tofu or Dofu; it has various names. This is a soft curd made by the coagulation of the soy-bean milk with calcium sulphate, raw salt, or by acid milk or whey. As it appears in the market, it contains about 83 to 88 per cent water, 7 to 11 per cent protein, 4 to 5 per cent. fat, and perhaps 0.5 per cent ash. In the fresh form it is comparable to low-grade Neufchatel or cottage cheese which runs about 10 per cent higher in nutritive constituents. The cakes of curd are usually about 2 inches square and 1 inch thick. These little cakes are ripened in cool, very moist rooms, until covered with a deep felt of mold; then packed in jars with excessive amounts of salt and allowed to cure slowly. The concentration of brine is such as to reduce the activity of microorganisms to a minimum. The final cheeses have high flavor, rather strong odor, and too much salt to be consumed in bulk as cheese. They are covered with red sauce and variously combined with other food products before consumptions.—CHAS. THOM, before the Botanical Society of Washington.

Researches in Far Eastern Seasonal Correlations

IN Northern Japan the August temperature is the dominant factor for the rice crop of the year, a high temperature being favorable to the crop. It is thus of great importance to arrive at some means of forecasting the temperature in August some months in advance. The author has previously traced a connection between this temperature and certain meteorological elements in other parts of the world earlier in the year. In the present paper correlation coefficients are worked out and regression equations formed. In calculating the correlation coefficients, differences of the various elements from one year to the next are used instead of departures from the normal. The regression equation connecting August temperature in Northern Japan with the Azores-Iceland pressure difference in the preceding April, with the pressure difference between Zikawei and Miyazaki in March, and with the pressure at Sydney, N. S. W., in January gives changes of temperature from one year to the next which are of the right sign in all except threeof the 24 years 1884-1907. Omitting the Sydney pressure term there were five errors in sign in a 29-year period. The largest correlation coefficient obtained is +0.61 between Japan temperature and Azores-Iceland press-difference.—Note in Sci. Abstr. on an article by T. OKADA in *Mo. Weather Rev.*

Plant Stimulation By Electricity

THE letters that have appeared recently in the *Times* and in articles elsewhere on the effect of electric action on the growth of plants show a readiness to believe that almost any wonders may be wrought by electricity. Most scientific workers will agree with Prof. Armstrong and Sir James Crichton-Browne in their scepticism as to the proved value of electrical treatment as a general method of increasing crop production. It is asserted that by the electrical treatment of seeds increases of yield of 20 to 80 per cent may be produced. The statement seems to refer to a commercial process in which, apparently, seeds are subjected to the combined action of electric currents and certain solutions; in the method electrolysis appears to play some part. The process seems based on the treatment known to physicians as "ionic medication," and used, for example, for the reduction of swollen joints. Treatment of seeds in this way appears to have no sound physiological basis, and no data derived from experiments carried out under critical conditions appear to be available, so that it is impossible to evaluate the method. No one who knows the difficulty of carrying out satisfactory agricultural experiments, and the ease with which a few favorable but illusory results can be obtained, is likely to accept the views of a few farmers as convincing evidence of the value of the process. The method of treatment of the growing plant with a high-tension discharge from overhead wires has been before the public for some years; it is certainly more promising, but it is generally admitted to be in a purely experimental stage.—*Nature.*

Carbonization of Wood in Inclined Retorts at Varta Gasworks, Stockholm

NEARLY one-half of the gas supply of Stockholm is now manufactured from wood carbonized in inclined retorts. To reduce the excessive proportion of carbon dioxide in the gas from wood, it is arranged that the lower half of the retort should always contain hot charcoal over which the gas passes on its way to the exit. A portion of the carbon dioxide is thereby converted into monoxide, but owing to the violent evolution of the gas in the early stages, much carbon dioxide passes unchanged. On discharging the retort one-half of the charge is left in the lower end. Fresh wood is piled above that and on top coal equal to one-tenth of the weight of wood. Coal is included to furnish hydrocarbons which on decomposition deposit carbon and so keep the retorts gas-tight, and also so that the ammonia liberated shall neutralize any acetic acid which may pass the hot charcoal undecomposed. The aqueous distillate is alkaline. The make of gas is at least 600 cub. meters per ton, of calorific value 3,000-3,300 kilo-calories per cubic meter. Fifty kilos of wood is charged every 2 hours, and the output of gas is approximately the same as that obtained when coal is carbonized, although the calorific value and the amount of useful coke produced are lower. The coke and charcoal mixture has been successfully used as fuel in gas producers.—Note in *J. Soc. Chem. Ind.* on an article by A. MOLIN in *J. Gasbeleucht.*

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